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FURTHER NEEDS IN WILDLIFE RESEARCH[1]

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From the standpoint of an administrator of our wildlife, I am convinced that this great resource cannot be directed or managed correctly without the guidance of both fundamental and applied research. Let us not forget the magnitude of the problem. More than 25 million Americans now enjoy the sport of fishing and hunting, and they are spending more than 4 billion dollars annually in the pursuit of their favorite recreation. The demands for more game and more fish are increasing constantly and will continue to do so for sometime to come if we, as wildlife administrators, scientists, and managers, can increase the supply of this resource. The directors of private industry or business with an investment worth even a thousandth part the value of this great resource would not think of proceeding without the constant guidance of research.

In addition to the economic benefits, this resource provides great aesthetic and spiritual appeal. This, reflected in better citizenship, better health, happiness, and greater national solidarity, is probably no less valuable than the economic returns.

Research honestly, objectively, and competently pursued has always paid great dividends. The conveniences, comforts, and blessings of modern life are the result of research. Let him who questions this enjoy an amputation or operation without benefit of anesthesia. Many of the benefits of research are taken for granted because they are now so commonplace. The steam engine, the incandescent bulb, the turbine generator, and the automobile, like innumerable medical discoveries, are largely taken for granted; yet they are the products of research.

In 1941 we produced and consumed some 10 billion dollars' worth of products that were entirely unknown before 1918. Science played a major role in World War II. The atomic bomb, radar, rockets, synthetic rubber, sulfa drugs, penicillin, D.D.T., 1080, and 2,4-D, as well as greatly improved aircraft, are but a few of the accomplishments of science during the war. Many of the means and procedures of warfare and production witnessed during World War II had not been considered possible

[1] Presented by Dr. Cottam at the symposium on "Research and Its Relation to the Administration of Wildlife and the Broad Field of Conservation" held by the Tenth Midwest Wildlife Conference in Ann Arbor, Michigan, on December 9–11, 1948.

even a few years earlier. Victory and the continuance of our American way of life were made possible through the close correlation of research, industry, and our war machine.

Progress in peace can become a reality only through application of those same basic principles which brought victory in war. Constantly changing conditions always will require new information and new techniques to meet new problems; hence research always will be an absolute necessity. Captains of industry realize this. It is reported that E. I. duPont de Nemours and Company is now spending some 30 million dollars to modernize its research facilities.

Perhaps we can better appreciate the benefits society is reaping from its investments in research when we realize that industrial research is actually less than 50 years old. The first crude chemical laboratory, developed by von Liebig in Germany, was established only 125 years ago. Science has already given evidence that our opportunities for future progress are limited only by the breadth of our powers of imagination and our *will* to work together for peace and progress. Our progress and, in fact, our national security are, I believe, dependent upon a continued and expanded program of research.

Proper utilization and conservation of our natural renewable resources are dependent upon scientific research. This is no less true in the field of wildlife conservation than in agriculture, industry, or public health. To control Nature, we must understand her processes and work with her.

Unless our people follow a wiser course, national disaster awaits us. Unforgiving Nature constantly reminds us that as we sow, so also must we reap. The dust storms which are again in evidence, the eroded and abandoned farm lands, overgrazed and ruined range lands, floods, lowered water tables, droughts, and dried-up streams provide unmistakable warning. They should convince us that conservation should not be regarded as the sentimental hobby or harmless pastime of impractical nature lovers, daydreamers, duck hunters, fishermen, or scientists; but rather that conservation and the necessary research to guide it had better be the urgent business of individuals, society, and government.

DIVIDENDS PAID BY RESEARCH IN WILDLIFE AND FISHERIES

Has research in wildlife and fisheries paid dividends? I want to answer this question with an emphatic YES. I want to shout to the four quarters of this country that the greatest remaining need is more and better research.

It may be of value to list a few of the many major accomplishments of wildlife and fishery research:

1. Research has done much to build public consciousness and appreciation of the value of these resources. We are not yet out of the woods, but much progress has been made, and the majority of our people now realize that renewable resources are neither limitless nor indestructible. Important factors in developing this concept have been our 10 cooperative wildlife research units; 4 more of these units have been established during the past year. Research at a few other great American universities—as the University of Michigan, Minnesota, Washington, Wisconsin,

Stanford, and Cornell—has contributed greatly to this better understanding. Certainly the very successful Federal Aid (Pittman-Robertson) program has helped to advance the cause. The education or public relations divisions of a number of the state conservation agencies have likewise furthered this cause.

2. Research in this field, as in other fields dealing with renewable resources, has developed the basic concept that soil, water, wildlife, forestry, and agriculture are inseparable facets of the over-all conservation program. These renewable resources are so inextricably intertwined that it is very difficult, if not impossible, to pick out any one and carry on a conservation program for that alone without affecting, for good or ill, other important resources. Any practice that adversely affects soil or water also affects the wildlife or fisheries adversely. The product of the soil or of a body of water can be no more numerous, no better in quality, than is warranted by the stock of raw materials in the soil or body of water. Frequently a wildlife map can be superimposed on a soil map. Research workers are showing us that eroded soils and soils unproductive of agricultural crops are also unproductive of wildlife. This leads to the conclusion that the starting point in wildlife rehabilitation and management is with the soil and its water supply.

3. Training personnel, developing techniques, and devising specific management procedures, our cooperative wildlife research units and the Pittman-Robertson program have aided materially in raising the standards of many State game departments. In many, if not most, State game and fish departments men trained in wildlife conservation are replacing personnel selected for political qualifications, and decisions regarding management are now being based upon biological facts and procedures rather than upon political expediency.

4. Research on waterfowl management has been an important factor in preventing the complete collapse of the sport of waterfowl shooting. Research on population fluctuations, censusing, ecological relationships, banding, migration, distribution, nesting, brooding and feeding habits, has given us much basic information necessary for management. Despite the fact that there is much yet to be learned, despite the fact that the birds run the gantlet of more than 90 days of legal hunting in Canada, the United States, and Mexico, and despite the problems of drought and agricultural encroachment, pollution, drainage engineers, poachers, politicans, and special interests—despite these conditions, we still have fairly liberal waterfowl hunting opportunities in most States, at least in comparison with the hunting of nonmigratory game in those same States. A generous share of the credit for this can justly go to research.

5. Research in botulism has paid encouraging dividends, even though (as with many human diseases) much remains to be learned. Thousands, perhaps millions, of birds already have been saved for the sportsman.

6. Credit is due to wildlife research for the development of management techniques for bob-white quail, pheasants, California quail, grouse, and other game birds in different sections of the country. In this connection, I might mention the "Gallinaceous Guzzler,"

developed by research workers in California to supply essential water in the semi-desert regions of that State. This storage and automatic watering device already has permitted the harvest of thousands of quail in areas where none or very few could survive even 2 or 3 years ago.

7. The development of hedges and fences with such perennials as multiflora rose, has provided cover and winter emergency food in areas where these essentials are at a premium.

8. Research on vitamin requirements of bob-white quail suggests a major cause of winter die-off in northern States and has pointed the way to much saner and more effective management at tremendously reduced costs. The same study showed the futility of continued introductions of pen-reared birds into areas north of the birds' normal range.

9. Research on mourning doves in Alabama has revealed the disastrous effects of September shooting in that State and perhaps in all other southern States.

10. Certain predator and rodent-control studes have shown the many benefits and limitations of control. Apparently predators of fairly high reproductive potential (e.g., coyotes) exert a serious and limiting influence on a prey species of noticeably smaller reproductive capacity (e.g., antelope). When the prey species has a much greater fecundity (e.g., rodents) than the predator (e.g., coyote), however, the predation can have very little biological effect. These studies have shown that the most effective, economical, and intelligent control for certain range rodents is to keep all grazing well within the carrying capacity of the land.

11. The new insecticides, herbicides, and rodenticides—such as D.D.T., 2,4-D, and 1080—are exceedingly toxic. Studies on the reactions of fish and wildlife to these toxicants have provided techniques designed to avoid excessive damage to desirable species.

Many benefits have resulted from fishery research. A few examples of the more important practical benefits:

1. Restoration of the Pacific halibut fishery.

2. Rehabilitation of the herring resource in southeastern Alaska.

3. Restoration of Fraser River salmon runs.

4. Re-establishment of Atlantic salmon runs on certain streams in Maine.

5. Technological research in filleting, storage, packaging, use of by-products and in production of vitamins. These studies have resulted in increased utilization of fishery resources.

6. Studies in hatchery methods and techniques. These studies have revealed conditions or situations where artificial propagation is justifiable and many other conditions or situations where artificial propagation is a waste of public funds.

7. Location of valuable off-shore shrimp resources in the Gulf of Mexico.

8. Improvement or development of oyster farming.

9. Design and improvement of fishways, fish screens, and other protective devices.

10. Development of the farm pond program. This has been particularly beneficial to fish and wildlife in the southern two-thirds of the United States.

11. Studies to permit the designation of waters suitable for planting or propagation of desired fish.

URGENT NEEDS IN RESEARCH

Research and management have no greater need than that decisions and actions pertaining to research and management be based upon biological facts rather than upon political expediency. Experience should have taught us by now that among the worst enemies of research—and, in fact, of all wildlife and fishery resources—are expedient, patronage-seeking partisan politicians of all brands.

The administrator should be chosen and retained solely on the basis of his competence and fitness for the job, not on the basis of his political affiliation. Until recent years, many States have had an almost complete turn-over in personnel following a change of political administration in the State. Research cannot prosper under such a situation. Possibly some administrators are not sufficiently informed and experienced to use available data. These men should either learn the facts or be replaced. Certainly this shows the need of keeping politics out of wildlife administration.

To ignore the public in a democracy cannot but prove disastrous. Research needs the confidence and understanding of the general public. I can assure the research workers and technicians that there are now relatively few administrators in this field who are not anxious to follow a policy of sound biology just as far as they can. We must all realize, however, that no administrator can long continue to follow policies and procedures contrary to public opinion and desire, and remain in office! In other words, a shrewd administrator must manage the public as well as the fish and wildlife. State legislatures or the Congress may enact laws and appropriate funds for measures that to most of us seem unsound biologically or unnecessary; at the same time, they may refuse to permit measures that we regard as profoundly important and desirable; or, a high Federal or State executive may make a ruling that is thoroughly disapproved by the wildlife administrator or research worker. In a neighboring State the management of the deer herd is contrary to biological facts and quite contrary to the wishes and recommendations of all administrators concerned with the problem. Similarly, research has demonstrated convincingly that bounties on predatory animals and birds usually are neither effective nor economical as a means of control; but ignorance, as well as political pressure, still causes too many States to waste their funds on a bounty system. Similar comments could be made about the indiscriminate stocking programs, which altogether too frequently are a waste of public funds.

Conservation of wildlife and fishery resources is comparatively young. Whether we like it or not, in many of our foremost educational institutions research in this field is scarcely recognized as scientific inquiry: at least, it is not yet accepted as being on a par with older and related but more fully developed sciences such as zoology, botany, ichthyology, ornithology, mammalogy, physiology, and nutrition. Consequently, the friends of wildlife—the administrators, the researchers, and the managers—must be thoroughly objective and constructively critical in establishing a firm and lasting foundation in this field. A top-notch scientist is always critical of himself and his methods. This critical, objective attitude must be applied in reviewing the field of wildlife

research, administration, and management.

We must freely admit that not all widlife research has paid off. In my opinion, three major factors have caused most of the failures in wildlife research. These are (1) incompetent research workers, (2) weak and improper administration of research, and (3) an unsympathetic, unsupporting public. For the advancement of research to the consequent advantage of the resource, we must acknowledge and amend our own shortcomings and win a favorable public opinion.

Part of a good supervisor's task is the careful selection of his research personnel. Let us have carefully selected, well-trained men, preferably with at least a year's apprenticeship on an operational project. In order that we may attract good researchers and retain them for a desirable period, let us compensate these men on a scale commensurate with their ability and their accomplishments.

Weak and improper administration has been responsible, I believe, for more research failures than is generally realized. We must have competent administrators who are well-trained in wildlife conservation, familar with the problems of research and management, and capable in public relations. We need emphasis placed upon the more urgent problems of management; we should have a scale of relative values to help determine the priority of research assignments. We need better planning and better supervision of research assignments, with more attention to detail, objective, and probable duration. We need some kind of simplified cost accounting for application to research assignments. A simplified system of cost accounting would assist in appraising the value of each assignment, would help to win support for the better type of research, and would serve to discourage any wandering from the immediate objective. Further, the administrator of research should see to it that there is more efficient application of the statistical approach, by this means making certain that the data obtained are significant. Perhaps it might be said that wildlife research generally has lagged behind fishery research with regard to the statistical approach, whereas some phases of fishery research have paid too little attention to the ecological approach.

Lack of public support, the third of the major factors believed responsible for most of the failures in wildlife research, may itself be the result of the first two factors—incompetent researchers and inadequate or improper administration. Research workers often are not good salesmen, but competent administration will make every effort to give favorable publicity to accurate research findings.

One of our most pressing needs is to develop a realization by the public that the problems of wildlife and fishery resources are as technical and as complex as the problems of most other fields. Perhaps it is because the conservation movement is young and our research is comparatively new, that we find a high percentage of hunters and fishermen assuming to themselves expert knowledge and wisdom concerning the factors responsible for wildlife or fishery abundance or scarcity. A lawyer, merchant, industrialist, or dentist—or other professional man—demands spe-

cialization in his own field and accepts statements and advice on management and procedure only from those skilled by extensive training and experience in his specialized profession. Unfortunately, the same individual often, if not usually, speaks and acts as the last word of authority in wildlife and fishery matters. He assumes that because he is a hunter or fisherman, because he uses or harvests wildlife or fish, he is an expert in that field; but usually his observations are isolated and unrelated, and his conclusions are based upon one or a few experiences. This attitude is as absurd as to assume that the individual who has the services of a doctor, engineer, or any other specialist, automatically becomes endowed with profound knowledge and skill in that special field. Proficiency in wildlife research and conservation comes the same way as it does in other fields of endeavor. When people generally appreciate this, wildlife research will receive better support.

There are many wildlife and fishery management problems that are urgently in need of solution. Let us consider but a few of these:

1. Because of the rapidly extended use of radioactive substances, because of the probable development and application of atomic power for industrial and domestic purposes, we must learn as soon as possible all that we can about the relation of radioactivity to our wildlife and fishery resources. The facts now available indicate that the most important effects of radiations are physiological. Radiations can cause direct injury to tissues and organs, and they may produce long-range genetic effects. We shall have to determine the safe limits of radiation exposure for our fish and wildlife populations in order to avoid extensive injury, lowered vitality, a reduced rate of reproduction, or even alterations in the physical form or function. On the other hand, we must explore the distinct possiblity that atomic energy may provide a clearer understanding of fundamental biological processes than we have obtained through the older chemical and physiological methods. Perhaps this new tool will solve the mysteries of nutrition and disease, of migrations and population fluctuations. Perhaps it can be utilized to determine the source, abundance, and role of the nutrients that favor multiplication of the "red tide" organisms that were so destructive last year along the coast of Florida. Perhaps some form of this energy can be used to reduce or eradicate overabundant rodent populations without causing injury to crops, livestock, or people. It is imperative that research be conducted along these lines as rapidly as possible.

2. About 80 per cent of our upland game is produced on the farm. Though we know much about such game, more research is necessary to permit better correlation of profitable agricultural practices and wildlife conservation. Little has been done to measure the effects of the various types of soil conservation and agricultural practice. We need more exact information on habitat requirements, on plant and animal successions and interrelationships.

3. For years we have known that lead poisoning was or could be a serious problem in the decline of waterfowl and perhaps also in the decline of other species. Recent studies suggest that the direct and indirect effects of lead shot

in the digestive tracts of birds may be an exceedingly important stumbling block in the restoration of waterfowl. At the close of hunting season live birds are carrying in their bodies an alarming amount of lead, and this condition may be much more widespread than we have realized. There is urgent need to ascertain the effects of the lead shot used in hunting, and to determine the role hunting plays in the loss of birds. We must know the extent of this loss, where it occurs, and what can be done to mitigate it. A concerted research program undoubtedly could develop a satisfactory substitute for lead, some substance that would not have the toxic properties of lead, yet also have satisfactory ballistic qualities.

4. Much is known of marsh management and plant control, but very much more along this line must be discovered before we can make the most efficient use of resources now at our disposal. There are many obnoxious pest-plant species that we still have very inadequate means of controlling. These plants frequently replace the many excellent duck food and cover species that are usually transition species in the ecology of the marsh. A thorough knowledge of marsh, upland and forest ecology is fundamental to wise and effective management of the wildlife forms inhabiting such areas.

5. We have too little information concerning cycles. We know that many species—grouse, rabbits, muskrat, waterfowl, and many others—are subject to cyclic fluctuations, but we know little concerning the cause of these cycles or what can be done to prevent cyclic declines.

6. There are few aspects of wildlife management that are more controversial or more complex than the subject of predator-prey relationships. Certainly we have great need of more basic data in appraising the effects of control programs. The ecological approach holds great promise, and this should be studied carefully. We need to know more about when, where, how, and under what set of conditions artificial control is in the public interest. Furthermore, we need more selective and effective means of control.

7. Throughout our country, billions of dollars are being expended for the development of river basins in the interests of reclamation, flood control, power, and navigation. Without the guidance of research, relatively little coordination of fishery and wildlife values on these extensive areas can or will be effected to secure even reasonable benefits for these resources.

8. It is urgent that we have more research on fishery resources. Until the past few months, we have known almost nothing of the spawning grounds, cycles, or movements of such valuable species as the tunas. The great wealth of our waters will be limited until research provides us with the basic facts of management and harvest.

9. It is imperative that research keeps pace with many new pesticides and herbicides that chemists are constantly producing. Most control agents are more or less specific in their reactions and effects upon animal or plant life. It is necessary, therefore, to determine the effects of these chemical controls upon fish and wildlife. We must determine not only the immediate direct effects, but also the indirect and long range effects upon succession in

lakes, streams, fields or forests. The studies on the effects of DDT and other insecticides have already paid huge dividends in saving wildlife from needless destruction. There is every reason to feel that our wildlife and fishery resources can be seriously and needlessly jeopardized unless this necessary research precedes and helps guide operational management in control.

CONCLUSION

The unsolved problems in wildlife and fishery management are legion, and the great complexity of many of these problems assures slow progress. It is well to remember, however, that such research, though slow and costly, is absolutely essential. It is well to remember that this country is spending more than 20 million dollars on cancer research this year and has spent millions of dollars on it annually for many years —and still the problem is far from solved and the research must continue.

Both fundamental and applied research are essential. A mature science must have both forms of research. Early research in nuclear physics must have seemed ethereal, academic, and perhaps a waste of efforts and funds. We know, however, that the dabblings with pitch balls and a glass rod rubbed with silk ultimately gave the world the power to make, manage, and use electricity. Wildlife research also holds important opportunities and possibilities.

Renewable resources can be used to the maximum capacity only when we understand them thoroughly and have proper tools of management. Research is the only means through which we can most advantageously use, conserve, and manage our resources. Our success will be assured if we have public support and cooperation.

NUTRITION OF BOBWHITE QUAIL

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Ten years ago the Fish and Wildlife Service (then under the old name of Bureau of Biological Survey) felt that a knowledge of nutritional requirements of upland gamebirds might help to uncover fundamental principles underlying their survival and increase. In 1938 the Service, in collaboration with the Bureau of Animal Industry, obtained funds under the Bankhead-Jones Act to start nutrition research on gallinaceous upland gamebirds. It chose the popular indigenous bobwhite quail as the first subject.

During subsequent years the project grew away from Bankhead-Jones support, and became firmly established in the Fish and Wildlife Service. Much information on the dietary requirements of bobwhites has been uncovered, but, as in the case of similar studies on domestic animals, only a very small portion of the vast field has been explored. Up to 1948, the research has involved primarily the requirements of quail for protein; four minerals, namely, calcium, phosphorus, sodium, and chlorine; and three vitamins, namely, vitamin A, riboflavin (formerly called vitamin B_2 and vitamin G), and pantothenic acid (formerly called filtrate factor).

This paper summarizes and evaluates the results of Federal research into bobwhite quail nutrition, since the beginning of the project to the present time. Observations on managerial problems, other than dietary, have been published from time to time, but are not considered here.

While it is true that pen-reared birds have been the chief subjects of study, and professional gamebird propagators have received much direct benefit from this research, these facts should not be permitted to becloud the principal goal and value of the project. Improved management of gamebirds in the wild state has been, and will continue to be, the primary objective of the Fish and Wildlife Service's nutrition research.

Most of the laboratory work has been conducted at the Patuxent Research Refuge, Laurel, Maryland, a 2,600-acre tract near the nation's capital. Much credit for helping the project along to its present stage goes to the vision, wise administration, sympathetic understanding, and encouragement of Arnold L. Nelson as well as to Clarence Cottam and Gustav Swanson. Also acknowledgment is due for the valuable assistance of the first game propagator associated with the author, W. W. Bailey,[2] and his successor, L. Llewellyn; for the faithful performance of duty by technician W. D. Williams and those that followed him; for the splendid cooperation of H. W. Titus, Alex C. Martin, L. C. Morley, H. W. Nelson, and N. R. Ellis; for the chemical aid by H. McClure, D. Darling, W.

[1] On April 26, 1948, Mr. Nestler transferred to the Office of Experiment Stations, U. S. Department of Agriculture, to supervise research on poultry.

[2] Col. W. W. Bailey lost his life at Cherbourg in World War II in the service of his country.

Kauffman, R. Stow, J. B. DeWitt, and J. V. Derby, and for the splendid cooperation and assistance of many other fellow-scientists, secretarial help, maintenance workers, state officials and conservation officers, members of the Civilian Public Service, and public-spirited sportsmen.

INVESTIGATIONS BY OTHER WORKERS

Practically no research was conducted on the nutrition of quail until the 1930's. J. B. Coleman, pioneer bobwhite breeder in Virginia, carried out an experiment on his farm, in which he placed more than a score of different kinds of seeds, including legumes as well as cereals, in separate containers, and studied the birds' selection. The birds practically avoided the legume seeds, which are found in large quantities in the crops of wild birds, and showed a marked preference for kaffir and the millets. At the University of Missouri, W. O. Nagel, in 1934, made an interesting study on the relationship between diet and extent of parasitism in the bobwhite. From his data he drew the tentative conclusion "that the presence of sorghum cane in the diet of bobwhite quail has a restraining effect on parasitism." L. C. Norris, of Cornell University, in his experiments on the protein requirements of quail chicks used protein levels of 21, 24, 27, 30, 33, and 36 per cent on battery-reared birds. The most rapid growth was obtained on the 27 per cent level, but the difference between the results at the 24 per cent and the 27 per cent level was not great. C. C. Bass of Tulane University sought a practical remedy for the "nose-picking" form of cannibalism in young quail in close confinement. From his results he concluded that "if, in addition to the usual diet, the birds are fed all the ground raw meat they will eat, and if it is kept before them all the time, nose-picking does not develop. Or, if it has already started, it stops as soon as they take to the raw meat."

NUTRITIONAL REQUIREMENTS OF BREEDING QUAIL

Protein, Quantity: Four experiments were conducted. In the first two, involving 48 pairs of quail each, six protein levels of 13, 15, 17, 19, 21 and 23 per cent were compared. In the last two, involving 96 pairs of quail each, six protein levels of 19, 21, 23, 25, 27, and 29 per cent were compared. The differences obtained in survival of the breeders at the various protein levels, and the fertility and hatchability of their eggs, were not statistically significant. However, there were indications that for the optimum hatch, the protein content of the diet should not be lower than 15 per cent. *Maximum egg production was obtained on the 23 per cent level of crude protein.* There was a tendency for the weight of the eggs to increase as the level of dietary protein was raised from 13 to 23 per cent, but at levels above 24 per cent there were no significant differences in weight. The consumption of feed increased in direct proportion with the increase in the crude protein content of the diet. For both cocks and hens, protein levels ranging from 19 to 25 per cent were satisfactory for maintenance of body weight. (Protein Requirements of Breeding Bobwhite Quail. Ralph B. Nestler, Woodrow W. Bailey, M. J. Rensberger and M. Y. Benner. Jour. Wildl. Manag. 8 (4): 284–289. Oct. 1944.)

Calcium and Phosphorus: A study was made with 72 pairs of birds to determine the effect of six different levels of calcium in the diet on the condition and reproduction of the breeders, and the quality of their eggs, when the phosphorus level was maintained at *0.78* per cent. Ca/P ratios of 1:1, 1⅔:1, 2⅓:1, 3:1, 3⅔:1, and 4⅓:1 were used. There was no significant effect of the level of dietary calcium on the survival or weight of the breeders. Feed consumption increased directly with the increase of calcium. *The highest production occurred on a Ca/P ratio of 2⅓:1 (1.82 per cent of calcium).* Differences in the production on this ratio and production on the other ratios, with the exception of 3:1 (2.34 per cent calcium) are statistically significant. Differences in fertility and hatchability of eggs are not significant. Nevertheless, there was a marked tendency for hatchability to reach its peak on the ratios of 2⅓:1 and 3:1. Although defective shells occurred on all six Ca/P ratios, the greatest percentage (27.0) was found on the 1:1 ratio, whereas the least (7.0%) appeared on the ratios of 2⅓:1 and 4⅓:1. No effect of the mineral content of the diet was noticed on the calcium and phosphorus content of the eggs until the breeding season was two-thirds over. Then there existed a direct correlation between the calcium content of the eggs and the calcium content of the diet, and a reverse correlation between the phosphorus content of the eggs and the calcium content of the diet.

A second experiment with 72 pairs of breeding quail was conducted the following year to determine the effect of six different levels of calcium in the diet on the condition and reproduction of the breeders, and the quality of their eggs, when the phosphorus level was maintained at *1:00* per cent. Calcium-phosphorus ratios of 1¼:1, 1⅔:1, 2⅓:1, 3:1, 3⅔:1, and 4⅓:1 were used. There was no significant effect of the level of dietary calcium on the survival and weight of the breeders. Feed consumption increased directly with the increase of calcium. *The highest production occurred on a Ca/P ratio of 2⅓:1,* but the differences in the production on this ratio and production on the other ratios, are not statistically significant. Likewise differences in fertility and hatchability of eggs are not significant. Although defective shells occurred on all six Ca/P ratios, the greatest percentage (16.0) was found on the 1¼:1 ratio.

A comparison of the results on 0.78 per cent of phosphorus with those on 1.00 per cent of phosphorus, reveals higher egg production, greater feed consumption, better maintenance of weight, and less defective egg-shells on the 1.00 per cent of phosphorus. However, these differences must be verifed by future work in which the phosphorus levels are tested simultaneously (Unpublished Progress Reports. "Calcium and Phosphorus Requirements for Breeding Bobwhite Quail." Reports 1 and 2. Ralph B. Nestler and James B. DeWitt).

Sodium Chloride: In a comparison of two per cent of salt with 0.5 per cent of salt in the diet of breeding quail, it was found that the higher percentage of salt did not act as an anaphrodisiac or genital sedative. There was no significant difference in the production or fertility of eggs. The hatchability of fertile eggs, however, was significantly greater on the high salt level than on the low

level. The moisture content of the droppings was greater on the two per cent level of sodium choloride. (Effect of Large Quantities of Common Salt in the Diet of Bobwhite Quail. Ralph B. Nestler. Journ. Wildl. Manag. 7 (4) 418–419. Oct. 1943.)

Grit: Grit as a grinding agent in the gizzards of breeding bobwhite quail is unessential for their welfare and reproduction. (The Mechanical Value of Grit for Bobwhite Quail. Ralph B. Nestler. Journ. Wildl. Manag. 10 (2): 137–142. April 1946.)

VitaminA: The survival of breeders on two experiments, their production and hatch of eggs, and the survival of their offspring to 10 weeks increased in direct proportion with the increased quantity of vitamin A in the diet, whether from fish oil, pure vitamin A, or carotene. *Optimum egg-production and hatchability, and survival of the offspring occurred on a vitamin A level of 6,000 I. U. per pound of feed.* Regardless of the quantity of vitamin A in the growth diet, only 30 per cent of the offspring survived from parents on 3,000 I. U., 42 per cent from those on 4,000 I. U., and 54 per cent from those on 6,000 I. U.

All the hens, save one, on the diet containing no vitamin A started production in May and laid an average of 12 eggs each before avitaminosis stopped activity. The first death from vitamin A deficiency occurred two weeks after the removal of the nutrient. Five survivors (3 females and 2 males) were brought back to a healthy condition from near death, by oral administrations of 10–30 drops of fish liver oil (3,000 I. U. per gram). All had severe ophthalmia, and one hen was totally blind, but all recovered completely and the hens resumed production 17–35 days after the first treatment.

Storage of vitamin A in the livers of the breeders was also in direct proportion to the level of vitamin A in the diet. Carotene was not stored as efficiently as true vitamin A. Hens stored less of the vitamin than cocks, undoubtedly because they were supplying the factor to their eggs. The deposition of vitamin A in the eggs and subsequently in the chicks was also in direct proportion to the level of vitamin A in the production diet. On all levels of vitamin A, less of the vitamin was supplied to the last hatch of chicks than to the first hatch. In fact, there was less of the nutrient in the livers of the *last* chicks from parents on 8,000 I. U. of vitamin A than there was in those of the first chicks from parents without vitamin A. This fact may account for the reputed poor success of second and third clutches of eggs from quail in the wild.

During the following winter when vitamin A was removed for four weeks from the maintenance diet of the first generation of birds, survival was in direct proportion with the quantity of the nutrient that had been in the production diet. Only 14 per cent of quail that had been on 2,000 I. U. of vitamin A in the summer survived, in comparison to 92 per cent of those on 8,000 I. U.

The effect of the parents' diet on the offspring was apparent even during the latter's breeding season a year later. Survival even then was directly influenced by the parents' diet. When true vitamin A was compared with carotene in the production-diets, the former gave better hatchability of eggs by 9 per cent units, and greater survival of offspring by 14 per cent units.

The breeders' weights, feed consumption, and egg fertility were unaffected by either the levels of vitamin A in the diet, or the source, whether true vitamin A or carotene. (Vitamin A, Vital Factor in the Survival of Bobwhites. Ralph B. Nestler. Transactions N. A. Wildlife Conf. 11: 176–194. 1946.)

NUTRITIONAL REQUIREMENTS OF GROWING QUAIL

Protein, Quantity: A total of 816 chicks were used in four experiments to compare six levels of protein, namely, 22, 24, 26, 28, 30, and 32 per cent. From the three standpoints of rate of growth, livability, and efficiency of feed utilization for the first 10 weeks of life, *the 28 per cent level of protein gave the best results.* However, during the ninth or tenth weeks, the highest efficiency of feed utilization was obtained on the 22 per cent level. The results indicate that after the birds have reached about two-thirds of their mature weight, the difference in efficiency between a diet containing 28 per cent of protein and one containing 22 per cent may be small enough to justify, in the interest of economy, the use of a diet containing the lower percentage of protein. (Protein Requirements of Quail Chicks for Growth, Livability, and Efficiency of Feed Utilization. R. B. Nestler and W. W. Bailey, Journ. Wildl. Manag. 6 (3): 185–193. July, 1942.)

Protein, Quality: Quail chicks, given a choice of balanced diets in which the essential difference was the protein supplement, showed preferences for a diet containing 49 per cent peanut oil meal, a diet containing a mixture of nine per cent meat and bone scraps (50 per cent protein) and 38 per cent soybean oil meal, and a control diet containing a mixture of 16 per cent dried buttermilk and 42 per cent soybean oil meal, over diets containing sardine or menhaden fish meal.

However, in feeding tests over a five-week period from the time the quail hatched, *diets containing 14 per cent sardine fish consistently gave high live weights, low mortality, and high efficiency of feed utilization. Diets containing 9–10 per cent menhaden fish meal produced results nearly as good as those containing 14 per cent sardine fish meal.*

Live weights, survivability, and efficiency of feed utilization of quail on a diet containing 9 per cent meat and bone scrap (50 per cent protein) were markedly better than those of quail on a diet containing 9 per cent meat scrap (55 per cent protein), but not as good as those of quail on diets containing fish meal without meat.

Bobwhite chicks grew and survived more successfully on diets containing either soybean oil meal or peanut oil meal as the sole protein supplement in the diet, than chicks on diets containing either linseed oil meal, cottonseed oil meal, or dried buttermilk as sole protein concentrates. However, they did not do as well as those on diets containing fish meal.

One hundred per cent mortality occurred among quail chicks on diets containing either linseed oil meal, cottonseed oil meal, or dried buttermilk as the sole source of protein. However, as only 10 per cent of a diet, all three of these concentrates gave satisfactory results. In fact, survivability of quail, and efficiency of feed utilization was nearly as good on a diet containing 10 per cent dried buttermilk, 10 per cent linseed oil meal, 10 per cent peanut oil meal, and 27 per cent soybean oil meal,

as on the diets containing fish meal. (A Comparison of Protein Concentrates from Animal and Plant Sources in the Diet of Growing Pen-reared Quail. R. B. Nestler, L. M. Llewellyn, and M. J. Rensberger. Journ. Wildl. Manag. 9(4):274–279. Oct. 1945.)

Two experiments were conducted with 444 chicks to ten weeks of age, to determine the level of milk by-products desirable in a diet having no other animal proteins. A maintenance diet composed primarily of ground yellow corn was fed in conjunction with the growth diets, from the sixth week through the tenth week. None of the differences in bird-weights at the end of ten weeks was significant. The highest efficiency of feed utilization was on the diet containing 2½ per cent dried buttermilk. The least mortality occurred on the diet containing 12½ per cent dried buttermilk and three per cent dried whey; the highest, on the diet containing no milk by-products.

Abnormal feathering, caused primarily by a deficiency of riboflavin, occurred among many of the birds. The incidence was greatest on the diet containing no milk by-products—diminished as the percentage of milk by-products in the diet was increased, and was lowest on the diet containing 12½ per cent dried buttermilk and three per cent whey. A higher level of milk by-products did not further eradicate the abnormality.

A rating based on survival and growth of the birds, feed consumption, efficiency of feed utilization, and normality of feathering, through the first ten weeks of growth, gave *first place to the diet containing 12½ per cent dried buttermilk and three per cent dried whey.* (Milk By-products in the Diet of Bobwhite Quail Chicks. R. B. Nestler and L. M. Llewellyn. Feedstuffs 18(32):42, 43. August, 1946).

Cereals: Of nine cereals used in the diet of growing quail, proso *millet consistently gave the best results considering survival, bird-weights, feed consumption, and efficiency of feed utilization.* Millet, kaffir, and buckwheat when fed as sole cereals gave results comparable to those obtained with yellow corn. Results on oats and rye as sole cereals were not very satisfactory. When quail chicks were given a choice of mashes based on the cereals under consideration, they showed the greatest preference for the one containing proso millet as sole cereal, and the least desire for that containing oat groats. However, none of the preferences was outstanding. Any of the cereals successfully replaced half of the corn in the diet, millet, wheat, and rye being the leading three.

When substituting for yellow corn, one should bear in mind that yellow corn is a fair source of carotene (provitamin A), whereas all of the other cereals mentioned herein are poor sources. Therefore, sufficient vitamin A or carotene should be supplied by means of other feedstuffs in order to prevent a deficiency of this important nutrient. (Corn Substitutes in the Diet of Bobwhite Chicks. Ralph B. Nestler. Feedstuffs 16 (30):18–20. July, 1944.)

Certain ground cereals, notably oats, may cause a mechanical injury of the intestines in bobwhite quail chicks, with subsequent hemorrhage and secondary infection. The incidence of this malady is related to the grind of the feed. From the standpoints of survival, live weights, and feed consumption of bobwhites through the eighth week, the *Hammer Mill 3/32 inch screen grind*

was found significantly better statistically than any of three other approximate sizes, namely, those from the 1/16," 1/8," and ¼" screens. (Food Particle Size and Quality in Relation to Disease in Artifically Propagated Quail Chicks. Don R. Coburn and Ralph B. Nestler. Jour. Am. Vet. Med. Ass'n. 110 (838):30–34. Jan., 1947.)

Calcium and Phosphorus: In four experiments involving 873 bobwhite quail, a comparison was made of calcium: phosphorus ratios of 1:1, 1⅓:1, 1⅔:1, 2:1, 2⅓:1, and 2⅔:1 in diets with phosphorus levels of 0.52, 0.75, 1.00, and 1.25 per cent. The results indicate that *level of phosphorus for optimum growth is about 0.75 per cent,* and *that calcium is about 1.00,* making a Ca/P ratio of 1⅓:1. Although the greatest efficiency of feed utilization occurred on the phosphorus level of 0.52 per cent, the live-weight and bone-ash of the birds at the end of 10 weeks were significantly lower than they were on the levels of 0.75 and 1.00 per cent phosphorus. Bone-ash of birds on a Ca/P ratio of 1:1 was significantly lower than that on any of the other five ratios, regardless of phosphorus level. There was a significant reverse correlation between the Ca/P ratio of the diet and the storage of vitamin A in the liver, storage being especially low on the ratio of 2⅔:1.

The low and high levels of calcium and phosphorus considered in these studies are abnormal, the low level especially being hard to obtain with common feedstuffs. Nevertheless, even on such levels, results were not disastrous. The growth of quail in the wild happens during a season when the birds have access to the minerals of the soil and in the abundant animal matter (mostly insects) as well as to minerals in plant material. Therefore, seemingly, calcium and phosphorus need not be critical nutrients for growing quail in the wild. (Calcium and Phosphorus Requirements of Bobwhite Quail Chicks R. B. Nestler, J. B. DeWitt, J. V. Derby and M. Moschler. Journ. Wildl. Manag. 12(1):32–36. Jan., 1948.)

Sodium Chloride: In two experiments involving 452 quail chicks, seven diets containing the following salt supplements, were compared: No additional salt; 0.25 per cent NaCl; 0.50 NaCl; 0.75 per cent NaCl; 1.00 per cent NaCl; 0.25 per cent Na_2SO_4; and 0.50 per cent KCl. All four diets containing sodium chloride gave about equal results in bird-growth, and produced better weights than the diet containing no additional salt. Survival was high on the 0.50 per cent, 0.75 per cent, and 1.00 per cent levels, especially the 0.75 per cent level. Feed consumption increased directly as the salt level of the diet was raised. The results on the Na_2SO_4 and KCl, while better than those on no saline supplementation, and somewhat inferior to those on NaCl, nevertheless are inconclusive because of inconsistency. (The Salt [Sodium Chloride] Requirements of Growing Bobwhite Quail. Ralph B. Nestler. Journ. Wildl. Manag. 13(1):121–123. Jan. 1949.)

Many newly-hatched quail tolerated as high as eight per cent of salt in the the diet for two weeks. However, evidences of salt poisoning occurred above the two per cent level of salt, the number of cases progressively increasing as the level of salt was raised to eight per cent. Pulmonary edema was the principal symptom. (Effect of Large Quantities of Common Salt in the Diet of Bobwhite Quail. Ralph B. Nestler.

Journ. Wildl. Manag. 7(4):418–419. Oct., 1943.)

Grit: Half of a group of 1,372 quail chicks on a normal growth mash was allowed access to insoluble, non-friable coarse sand from hatching time. Grit of larger particles was supplied as the birds grew older. The other half of the birds, similar to the first in age and pedigree, were fed no grit during the growth period. At all times the birds were kept on wire floors. The chicks that received no grit equalled or surpassed those on grit in survival, vice prevention, rate of growth, and efficiency of feed utilization. (The Mechanical Value of Grit for Bobwhite Quail. R. B. Nestler. Journ. Wild. Manag. 10(2):137–142. April, 1946.)

Vitamin A: Chicks without access to vitamin A, although from parents that received a high level, were all dead from avitaminosis within three weeks after hatching. Both survival and growth increased in direct proportion with the increase of the vitamin A content of the growth diet, until they reached a maximum at the *3,000 I. U. level per pound of feed.* Higher levels of 4,000 and 5,000 I. U. produced a slight but not significant increase. True vitamin A in comparison with carotene gave better growth, but not better survival, at all levels from 500 to 2,500 I. U.

The young stocks' survival during the winter, regardless of the level of vitamin A in the maintenance diet, was in direct relationship with the level of vitamin A in the growth diet. When all vitamin A and carotene was eliminated from the winter diet, the average number of days that the birds survived increased in direct proportion with the vitamin A in the growth diet. This variation ranged from only 13 days for those that had received as low as 500 I. U. of vitamin A, to 50 days for birds that had received ten times that quantity, or 5,000 I. U. Death from avitaminosis struck quickly only six days after the removal of the vitamin, and claimed 93 per cent of the birds before the end of four weeks. When a small quantity of vitamin A, only 500 I. U., was incorporated into the maintenance diet, mortality was delayed to some extent and only 32 per cent of the birds succumbed in the first four weeks.

During the period of growth less than 20 I. U. of vitamin A per gram of liver were stored by the birds, except where the quantity of the factor in the feed exceeded 2,000 I. U. per pound. Storage increased heavily in direct proportion with the level of vitamin A in the diet as the latter rose from 2,000 to 5,000 I. U. Birds from parents on low levels of vitamin A stored less than did those from parents on high levels of vitamin A. Quail on 5,000 I. U. of true vitamin A stored significantly more of the vitamin than did those on 5,000 I. U. of carotene.

The level of vitamin A in the growth diet had no significant effect on subsequent production, fertility, and hatchability of surviving quail, when a maintenance diet adequate in the vitamin, was fed during the intervening winter. (Vitamin A, Vital Factor in the Survival of Bobwhites. Ralph B. Nestler. Trans. N. A. Wildlife Conf. 11:176–194. 1946).

According to studies conducted with 236 bobwhite quail chicks, crystalline carotene in cottonseed oil fed at levels of 3,000 I. U. (the requirement for optimum growth), and 5,000 I. U. per pound of feed, was utilized only one-

third to one-seventh as efficiently as vitamin A alcohol; one-half to one-tenth as efficiently as natural vitamin A ester; and one-fourth to one-seventeenth as efficiently as synthetic vitamin A acetate, based on the storage of vitamin A in the liver.

The carotene in the natural carrier alfalfa leaf meal was assimilated as effectively as was crystalline carotene in cottonseed oil, when both were fed at 5,000 I. U. per pound of feed.

Crystalline carotene when fed at a level over eight times the requirement of the quail for maximum growth, or 25,000 I. U. per pound of feed, was stored as vitamin A in the livers of the pen-reared quail to an extent comparable to the levels found in certain young wild quail.

Vitamin A acetate was utilized more efficiently by quail than either vitamin A alcohol or the natural vitamin A ester.

There was considerable individual variation in storage of vitamin A by quail on the same diet, and with the same or similar parental background. (Storage by Bobwhite Quail of Vitamin A Fed in Various Forms. R. B. Nestler, J. V. Derby, and J. B. DeWitt. 36 (2): 323–330. Jour. of Nutr. Aug., 1948.)

An early symptom of vitamin A deficiency in young quail is ruffled feathering with the wing primaries standing out from the body and drooping. Ophthalmia in one or both eyes occurs and may close the eyes completely. However, this condition is not severe in all cases and may not even be noticeable. Birds show poor growth, loss of appetite and weakness before death. Mortality is high.

Postmortem examination may reveal visceral gout with thick deposits of urates on the kidneys, in the ureters, on the heart, in the proventriculus and, occasionally, covering all the internal organs. Pale kidneys and engorged ureters are typical. Also there may be hemorrhage of the heart or other organs.

A growing mash for quail which contains sufficient vitamin A when fresh may, after a period of storage, lose enough of the vitamin to cause the characteristic symptoms of avitaminosis A to appear. (Vitamin A Deficiency in Quail. Ralph B. Nestler and Woodrow W. Bailey. Journ. Wildl. Manag. 7(2):170–173. April, 1943.) (Visceral Gout a Symptom of Vitamin A Deficiency. Ralph B. Nestler. Journ. Wildl. Manag. 9(3):255. July, 1945.)

Riboflavin and Pantothenic Acid: In the growth study with milk by-products previously discussed under "Protein, quality," an abnormal juvenal feather growth, in which primary and secondary wing feathers were curved, twisted, stunted, and in some cases frizzled, occurred among many quail chicks. It was most prevalent on the diet containing no dried milk-products. The evidence diminished as the percentage of milk-products in the diet was increased, but appeared in a few birds even on the diet containing 15 per cent dried buttermilk and three per cent dried whey. A test with riboflavin and pantothenic acid as supplements gave evidence that riboflavin (vitamin G) apparently was the major, but not sole, cause of the abnormality. The incidence of the malformation was also consistently and significantly greater among birds receiving vitamin A and D feeding oil fortified, than among those receiving D-activated animal sterol. (Abnormal Feathering of Pen-reared Bobwhites. Ralph B. Nest-

ler and Leonard M. Llewellyn. Poul. Sci. 23(1):72–75. Jan., 1944.)

In two experiments involving 519 bobwhite quail chicks, the following six levels of riboflavin were compared: 800, 1,000, 1,500, 2,000, 2,500, and 3,000 micrograms per pound of feed. The best survival (81 per cent) to the end of ten weeks occurred on *2,500 micrograms of riboflavin;* the poorest (60 per cent and 59 per cent respectively) on 800 and 1,000 micrograms. All bird-weights obtained on 1,500 micrograms of the vitamin, as well as on the higher levels, were significantly greater than those obtained from the two lower levels of riboflavin. Feed consumption increased as the level of the vitamin was raised. The storage of either riboflavin or vitamin A in the birds' livers was unaffected by the quantity of riboflavin in the diet. No curled-toe paralysis was manifested even on 800 micrograms of riboflavin.

Abnormal feathering existed with most of the birds, even though it had been reduced successfully in the previous study by additional riboflavin. This discrepancy in the results from the two studies was due to the fact that the basal feed mixtures differed radically as to the inclusion of certain ingredients. Seemingly another member of the vitamin B-complex might be involved, a factor that must have been present in the feed mixture of the previous study in nearly adequate quantity, but was deficient in the diet of the present-mentioned experiments. On this supposition a special test was run with 210 chicks. The basal feed mixture of the later study was supplemented with pure crystalline riboflavin to supply 2,500 micrograms of riboflavin per pound. To this was added separately the following factors: thiamin, calcium pantothenate, pyridoxine, chlorine, inosotol, niacin, p-aminobenzoic acid, pteroylglutamic acid (folic acid), and biotin. Only the diet containing additional pantothenic acid produced normal feathering. None of the others had a significant effect. (The Riboflavin Requirements of Bobwhite Quail for Growth and Normal Feathering. R. B. Nestler, J. B. DeWitt and J. V. Derby. Unpublished report.)

Nutrition and Picking: During five years of nutritional research on pen-reared bobwhite quail, observations were made on picking among the birds as follows:

1. Picking occurred on all cereals tested: corn, wheat, oats, oat groats, barley, millet, buckwheat, kaffir, and mixtures of cereals. The lowest incidence occurred on buckwheat as the sole cereal in a growing diet.

2. Picking occurred on all levels of fiber from one to 11 per cent in a growing diet.

3. Picking occurred on various grinds of corn, barley, and oats, but the least was seen when these cereals were ground in a hammer mill with 3/32 inch mesh screen.

4. The incidence was as high on diets containing animal protein as on those containing no animal protein.

5. After picking began, the addition of one or two percent of salt to the diet for several days was effective, in many instances, in checking the disorder. According to results obtained at the Refuge and the answers to questionnaires from 222 private propagators of gamebirds, in two cases out of three, treatment with the increased quantity of salt successfully stopped the trouble. As a preventative, however, salt was

of little value. Picking occurred on both low and high levels of salt.

6. Supplementing the regular diet with certain feed concentrates such as fish meal, soybean oil meal, liver meal, or chopped greens offered in a separate feeder for a day or two, was as efficacious in checking picking as was the addition of salt.

7. More picking occurred among quail chicks on a 22 per cent level of protein than on higher levels.

8. There was less picking on diets that were relished by the birds than on diets that were seemingly unpalatable.

9. There was no correlation between the amount of total floor space per chick and the incidence of picking, but increasing the feeding and drinking space seemed to have a marked beneficial effect.

10. Some grown birds on wire floors resorted to self-picking of their feet after their toes were frost-bitten. (Picking among Pen-reared Quail. Ralph B. Nestler, Don R. Coburn and Harry W. Titus. Journ. Wildl. Manag. 9(2):105–114. April, 1945.)

NON-PRODUCTIVE MATURE BIRDS IN WINTER

Protein Quantity: Three experiments involving 714 bobwhite quail were conducted to determine the protein requirements of quail maintained through the winter. Considering survival, live weights, and feed consumption, and subsequent reproduction of the birds, the 9 to 11 per cent levels of dietary crude protein gave as good results as higher levels, and in some respects better. On the basis of these studies, it is recommended that the winter maintenance diet for bobwhite quail contain about 11–12 per cent of crude protein. The following diet suggested in Conservation Bulletin No. 10 of the U. S. Department of the Interior conforms to these specifications and should be satisfactory:

	per cent
Ground yellow corn	85.3
Dehydrated alfalfa leaf meal	5.0
Soybean oil meal	7.0
Special steamed bonemeal	1.2
Common salt or salt mixture	1.0
Vitamin A and D Feeding Oil Fortified	0.5
	100.0

(Winter Protein Requirements of Bobwhite Quail. Ralph B. Nestler, Woodrow W. Bailey, L. M. Llewellyn, and M. J. Rensberger. Journ. Wildl. Manag. 8(3):218–222. July, 1944.)

Cereals: The comparative feeding values of corn, wheat, oats, barley, rye, and a combination thereof in a maintenance diet for winter use, were studied in two experiments involving 518 mature quail. White corn was accepted as readily as yellow corn after the birds became accustomed to it. Corn was the favorite grain, and wheat, the second choice. Oats, barley, and rye were partaken of very sparingly when corn and wheat were available. Maintenance mashes based on corn or wheat as the sole cereal were preferred to one containing a mixture of corn, wheat, oats, barley and rye. The lowest feed consumption was on the diet containing corn as the sole grain. Mortality on the diets containing either corn or barley was significantly lower than that on any of the other diets. Bird-weights increased on all of the diets. "Picking" occurred to some degree on all the diets except that based on corn alone, the most severe outbreak being on the oat diet. Ground rye as the sole cereal

in the maintenance diet caused caking of beaks. Replacement of 50 parts of rye in the diet with an equal quantity of corn checked the trouble. Likewise, caking did not occur when whole rye kernels were fed in conjunction with mash containing rye. Birds on the diet containing ground oats alone suffered severely from cold, in marked contrast to quail using other cereals. Quail fed whole oats endeavored to hull the grain before consuming it. On the basis of mortality, maintenance of live weight, feed consumption when no choice existed, and preference in instances where choice was possible, the feeding value of the cereals for the bobwhite quail, with corn rated as 100, was as follows: corn, 100; wheat, 77; mixture of cereals, 76; barley, 75; rye, 72; and oats, 67. (A Comparison of the Five Major Cereals in the Maintenance Diet for Bobwhite Quail. Ralph B. Nestler, Woodrow W. Bailey, and William D. Williams. Game Breeder and Sportsman 49(3, 4). Mar. & Apr., 1944.)

Grit: Quail reared without access to grit, when continued on a gritless regimen during the winter while fed a diet of whole seed, namely, wheat, proso millet, milo, soybeans, Canada field peas and Augusta vetch, survived and maintained their weight as successfully as birds on insoluble, non-friable grit. There were no gizzard lesions, and the digestion of whole seeds was satisfactory. Subsequent health and reproduction were unaffected by the absence of grit. Quail reared with access to grit retained an appreciable supply of grit in their gizzards for five months after being deprived of it. (The Mechanical Value of Grit for Bobwhite Quail. Ralph B. Nestler. Journ. Wildl. Manag. 10(2):137–142. Apr., 1944.)

Vitamin A: One thousand units of vitamin A per pound of maintenance diet gave optimum livability during the winter, and kept the birds in good condition, but was insufficient for subsequent egg production which was markedly affected by the vitamin A potency of the maintenance diet. Optimum production occurred among birds that had received 2,500 or more units of vitamin A. Apparently the reason for this effect on production is that no appreciable quantity of vitamin A was stored until the level of the vitamin in the diet reached 2,500 I. U. per pound. This fact indicates that, despite appearances, the body's requirements for maintenance were *not met by 1,000 I. U. per pound of feed.* Birds that received low levels of vitamin A in their growth diet stored proportionately less vitamin A than did those that received high levels in the growth diet. Likewise, at 5,000 I. U. there was significantly greater storage from true vitamin A than from carotene. In fact the storage from carotene was no greater than that from the levels of vitamin A below 2,500 I. U. Birds on 5,000 I. U. of carotene showed greater increases in weight during winter than did those on the equivalent quantity of true vitamin A. At the low vitamin A level of 500 I. U. per pound of diet, survival was more than twice as great on true vitamin A as on carotene. The quantity of vitamin A in the maintenance diet had no effect on food consumption, maintenance of weight, or subsequent fertility and hatchability of eggs. (Vitamin A Vital Factor in the Survival of Bobwhites. Ralph B. Nestler. Trans. N. A. Wildl. Conf., 11:176–194. 1946.)

Wild Feedstuffs: Pen-reared bobwhites were maintained through winter

successfully on diets containing 50 per cent of a high-caloric commercial seed mixture with yellow corn as the principle cereal, and 50 per cent of each of the following wild fruits: bayberry, wax myrtle, smooth sumac, Korean lespedeza, common lespedeza, willow oak, water oak, sweetgum, panic grass, partridge-pea, loblolly pine, buttonweed, ragweed, black locust, bullgrass, and crabgrass. From the standpoint of palatability and acceptability, the seed of common ragweed (*Ambrosia artemisiifolia*) and shrub lespedeza (*Lespedeza bicolor*) are preferred wild foods for pen-reared quail. (The Comparative Value of Various Wild Feedstuffs in the Winter Feeding of Pen-reared Bobwhite Quail. R. B. Nestler, W. W. Bailey, and A. C. Martin. Journ. Wildl. Manag. 9(2):115–120. April, 1945.)

The seeds of *Crotalaria spectabilis* are poisonous to bobwhite quail. Under ordinary conditions, however, they are not eaten by the birds when there is a choice of food. In fact, some quail starve rather than eat the toxic material. If a few seeds of *C. spectabilis* are picked up accidentally, or otherwise, by the quail, there is a good possibility that they will be defecated undigested, and so do little harm. (The Toxicity of *Crotalaria spectabilis* Seed for Quail. R. B. Nestler and W. W. Bailey. Journ. Wildl. Manag. 5(3):309–313. July, 1941.)

When whole sumac fruits were force-fed to quail, either alone or in combination with millet seed (*Panicum miliaceum*), many of the sumac seed were defecated undigested, whereas the millet seed were digested. Likewise, many sumac seed passed through the quail undigested when sumac fruit was fed ad libitum subsequent to a fasting period.

Quail did not relish sumac fruits as the sole article of diet. They lost weight nearly as rapidly on the fruit, ground or whole, the ground seed, or the pulp, as they did when not given any food. The birds maintained their weight for 14 weeks during the late fall and winter in out-door pens on a diet containing 50 per cent sumac fruit-pulp and other feedstuffs of high feeding value, but developed a severe neck moult during the ninth week. Quail lost weight rapidly on a diet containing 75 per cent sumac, even though kept away from adverse weather conditions. A severe neck moult took place during the first week of this high-sumac diet, and a heavy mortality occurred during the third and fourth weeks. Where the birds had a choice of many feedstuffs, they made sumac fruits two to four per cent of their diet. (Sumac Fruit as a Food for Bobwhite Quail. R. B. Nestler and W. W. Bailey. Am. Midland Naturalist 31(3):684–696. May, 1944.)

Lespedeza juncea, in comparison with two foods well-accepted by quail, namely, shrub lespedeza (*L. bicolor*) and partridge-pea (*Cassia chamaecrista*) was eaten, but not to the same extent as the other two items. Nearly four times as much shrub lespedeza was taken, and over twice as much partridge-pea.

In a study with the caley pea and blue lupine, both foods were used by quail without producing a toxic effect, but neither was a preferred article of diet. In the ground state, and in large quantities, lupine seeds were apparently very unpalatable.

When given a choice of six unfamiliar foods, namely, mung beans, August vetch seed, partridge-peas, shrub lespedeza seeds, juncea lespedeza seeds, and

black locust seeds, quail made the mung beans first choice (54.7 per cent of diet) and shrub lespedeza second choice (35.7 per cent of diet). (Acceptance of Four Legumes by Bobwhite Quail. Ralph B. Nestler. 13(1): 143–144. June 1949.)

Two tests were conducted to determine whether pen-reared quail prefer germinated seed to ungerminated seed. In Test No. 1, water oak acorns (*Q. nigra*), wild beans (*Strophostyles helvola*) yellow corn, and black locust seeds (*Robinia pseudo-acacia*) were made available in the freshly germinated state as well as ungerminated. In Test No. 2, seeds of Korean lespedeza (*Lespedeza stipulacea*) were made available ungerminated as well as germinated and dried at 100 F. Except in the case of the wild beans, no preference was shown for germinated seed over the ungerminated. In fact, there was a tendency, especially in the case of the dried lespedeza, for the ungerminated seed to be preferred. Over a period of six weeks quail maintained their weight as satisfactorily on a diet containing 50 per cent ungerminated lespedeza as on one containing 50 per cent germinated lespedeza. (Germinated Seed versus Ungerminated Seed in the Diet of Adult Bobwhite Quail. Ralph B. Nestler. Poul. Sci. 22(3):227–229. May, 1943.)

Supplements to Yellow Corn: In a study with 270 bobwhite quail, yellow corn alone as a maintenance diet helped the birds to survive the winter and reproduce as successfully during the subsequent breeding period as did corn supplemented progressively with cotton seed oil, vitamin A, vitamin D, salt, bonemeal, alfalfa leaf meal, soybean oil meal as a plant protein, and liver meal as an animal protein. The addition of salt to the corn helped the birds to maintain their weight better through the winter, than when either corn alone or corn plus oil and fat-soluble vitamins was fed. Also alfalfa leaf meal as a supplement tended to improve maintenance of weight. Nevertheless, whatever advantage was gained in weight-maintenance during the winter by the quail on diets containing salt and alfalfa, was lost during the subsequent breeding season. At that time those birds that had been on either yellow corn alone, or corn plus oil and fat-soluble vitamins, held their weights better than the others. The presence of bonemeal in the diet seemed to be advantageous only at the time just prior to the start of the reproduction period. Animal protein, showed no advantage over plant protein, and neither improved the diet containing alfalfa leaf meal. (Supplements to Yellow Corn for Winter-Maintenance and Subsequent Reproduction of Quail. Ralph B. Nestler. Journ. Wildl. Manag. 13(1):123–126. Jan. 1949)

Survival of quail and maintenance of their weight during a period of twenty weeks was poorer on white corn supplemented with 7,000 I. U. of true vitamin A than on white corn supplemented with 4.5 per cent dehydrated alfalfa leaf meal providing only 1,000 I. U. carotene. These results indicate that white corn is deficient in another factor, or other factors, than carotene, vital for quail during winter. So far, it is known that white corn is lower than yellow corn in riboflavin, niacin, thiamin, and phosphorus, as well as carotene. Also there is a possibility that it may have less of other factors besides the above mentioned. (Vitamin A and Carotene Supplements to White Corn

Diet for Quail Maintenance. Unpublished report.)

SUMMARY

Breeding Quail: For optimum reproduction, breeding quail required in their diet 23.0 per cent of crude protein, 1.0 per cent of phosphorus, 2.13 per cent of calcium, and 6,000 I. U. of vitamin A per pound of feed. One per cent of sodium chloride gave satisfactory results.

Growing Quail: For optimum growth and normal feathering quail required in their diet 28.0 per cent of crude protein, 0.75 per cent of phosphorus, 1.00 per cent of calcium, 0.75 per cent of sodium chloride, 3,000 I. U. of vitamin A per pound, and 2,500 micrograms of riboflavin per pound. Both pantothenic acid and riboflavin were required in adequate quantities to prevent abnormal feathering.

Diets containing either sardine fish meal or menhaden fish meal gave outstanding results from the standpoints of growth, survival, and efficiency of feed consumption.

Yellow corn and millet were the leading cereals for optimum growth of quail, whereas oats and rye, especially as sole grains in the diet, were not very satisfactory.

A disease complex due to mechanical injury from certain cereals occurred in quail chicks. From the standpoints of survival, weight, and feed consumption of bobwhite chicks and incidence of the disease complex, grind of cereals with Hammer Mill 3/32 inch screen, gave better results than grinds with 1/16," $\frac{1}{8}$," and $\frac{1}{4}$" screens.

Insoluble, non-friable grit as a grinding agent was not needed by quail.

Increasing the feeding and drinking space seemed to have a marked beneficial effect in the prevention of picking. Less picking occurred among chicks on diets high in crude protein than diets low in crude protein. Likewise, less picking occurred among quail chicks on cereals ground with the Hammer Mill 3/32 inch mesh screen, than with screens of other standard meshes. The addition of one or two per cent of salt to the diet for several days, or the supplementing of the diet with certain feed concentrates, such as fish meal, soybean oil meal, or chopped greens, for a short while, was efficacious in checking picking after it started.

Non-Productive Mature Birds in Winter: For successful maintenance in winter and subsequent reproduction, 12.0 per cent of crude protein was entirely satisfactory, and 3,000 I. U. of vitamin A per pound of feed was found to be desirable.

Yellow corn was the leading cereal for maintenance.

Grit as a mechanical agent was unnecessary for quail during winter, even though whole seeds were being fed. Quail with access to grit during the growth period retained an appreciable quantity of grit in their gizzards for five months after being deprived of it.

From the standpoints of palatability and acceptability, the seed of common ragweed (*Ambrosia artemisiifolia*), shrub lespedeza (*Lespedeza bicolor*), and mung beans (*Phaseolus aureus*) were preferred foods for pen-reared quail.

Sumac fruits were a poor diet for quail when they comprised over fifty per cent of the diet. Where the birds had a choice of many feedstuffs, they made sumac fruits two to four per cent of their diet.

Seeds of *Crotalaria spectabilis* were poisonous to quail, but under ordinary conditions, when there was a choice of

feedstuffs, they were not eaten.

The addition of salt to a yellow corn diet containing additional vitamin A, helped quail to maintain their weight better through the winter. Also alfalfa leaf meal as a supplement tended to improve maintenance of weight. The presence of bonemeal in the diet seemed to be advantageous only at the time just prior to the start of the breeding season.

There were indications that white corn is deficient in another factor, or other factors, than carotene, vital for quail during winter.

EVALUATION OF RESULTS AND RECOMMENDATIONS

Most of the findings obtained are useful to feed manufacturers and gamebird propagators. One finding at least seems to have bearing on the cause of quail disappearance in the northern part of the United States. Pen-reared quail cannot survive long without access to vitamin A or its precursor carotene, even though they may have an abundance of many foods that are wholesome and nutritious but deficient in this factor.

Unfortunately, we have little proof so far that vitamin A deficiency is serious in the wild, although we suspect it may be especially during times of adverse weather. A field investigation in Iowa and Wisconsin during the winter 1947–48, in which nearly 500 quail were obtained for vitamin A tests, disclosed no cases manifesting deficiency. Many had a low storage of vitamin A in their livers, which condition might have caused avitaminosis if the birds had had to endure carotene deprivation for several weeks, but, frankly, this possibility is only a conjecture. Two or three cases of visceral gout would have been more convincing evidence of the danger of deficiency in the wild. (Journ. Wildl. Manag. 13(3): 265–271. July, 1949.)

Long before the prominent symptoms of nutritional deficiency are manifested, the victims become less alert and agile. Therefore, they fall easy prey to carnivores and aerial predators. There is little chance that a research worker might find a bird in the wild manifesting a deficiency in the acute state, unless he can conduct his research on small islands where he would be able to have better control over both game and carnivores than on the mainland.

Nevertheless, even if we may never obtain positive proof of vitamin A deficiency in the wild, we can still make recommendations to game managers on the basis of our laboratory work, which should be beneficial to the wildlife. In addition to an abundant supply of protective cover for gamebirds, and foods high in easily digestible carbohydrates for heat and energy, there should be plenty of highly pigmented foods for the carotene or provitamin A. Such foods should be acceptable to gamebirds, and accessible even in times of deep snowfalls.

Yellow corn kernels, Japanese rose hips (*R. multiflora*), common wild rose hips (*Rosa sp.*), smartweed seed (*Polygonum punctatum*), bittersweet fruits (*Celastrus sp.*), mung beans (*Phaseolus aureus*), and sumac fruits (*Rhus glabra* and *Rhus copallina*), are foods known to be high in carotene. Of course, some of such carotene-containing materials, like sumac fruits, would not by themselves support birds very long. Birds must have a diet in winter high in easily digestible carbohydrates as well as in carotene. Fortunately, yellow corn combines both vital nutrients. (Journ.

Wildl. Manag. 13(3): 271–274. July, 1949.)

Nutrition studies on gamebirds would be greatly furthered by the use of islands for controlled field studies. Without controlled field work it is very difficult, if not impossible, to determine if the results obtained under laboratory conditions do apply to game under natural conditions. In fact, controlled field research is highly desirable for other phases of conservation and management of wildlife, as well as that of nutrition. The observational method for making measurements of individual factors affecting mobile wild populations of game, has been found inadequate for the solution of wildlife problems. There are involved too many variables, such as predation, climatic vagaries, time, soil fertility, food supply, unrestricted movements of the subjects, etc. The control of one or more of these factors would permit a clearer examination of the effect of the others. Islands would be helpful in such research by offering natural, rather than artificial, limitation to the movements of subjects, and control over carnivores and other factors. Although it may never be possible to make one hundred per cent accurate measurements on factors affecting wildlife, nevertheless, there is certainly room for improvement in the approach now being used. Islands offer many opportunities to correct past limitations of field studies. Therefore it is hoped that suitable islands in various parts of our country will some day be available for field studies on all phases of wildlife conservation and management.

FEED FORMULAS FOR QUAIL BASED ON RESULTS

Reproduction Diet:	*Per Cent*
Ground yellow corn	32.7
Standard wheat middlings	10.0
Dehydrated alfalfa leaf meal	10.0
Dried skimmilk or buttermilk	5.0
Sardine fish meal	5.0
Soybean meal	30.0
Special steamed bonemeal	3.1
Ground limestone	2.7
Salt mixture[1]	1.0
Vitamin A and D Feeding Oil fortified[2]	0.5
	100.0

Growth Diet:	
Ground yellow corn	38.3
Ground millet	10.0
Dehydrated alfalfa leaf meal	5.0
Sardine fish meal	14.0
Soybean oil meal	26.6
Flavin concentrate (such as B-y Feed, Curbay and Produlac or similar alcohol fermentation residues)	4.0
Ground limestone	0.6
Salt mixture[1]	1.0
Vitamin A and D Feeding Oil fortified[2]	0.5
	100.0

Maintenance Diet for Holding Quail During Winter:	
Ground yellow corn	85.3
Dehydrated alfalfa leaf meal	5.0
Soybean oil meal	7.0
Special steamed bonemeal	1.2
Salt mixture[1]	1.0
Vitamin A and D Feeding Oil Fortified[2]	0.5
	100.0

[1] Salt mixture consists of 100.0 parts of iodized salt (NaCl) plus 1.7 parts of manganous sulphate.

[2] Oil should have a potency of 3,000 I.U. of vitamin A and 400–425 I.U. of vitamin D per gram. In place of the oil, a dry carrier, such as Viadex, AD-Seal-In, Dry Vitamins A and D_3, Vit-AD, Vitinic Dry A and D, and others, may be used. Adjustment should be made in the formulas between the corn and the vitamin carrier to allow for differences in the vitamin A potency of the various carriers.

TWENTY YEARS OF BIRD BANDING AT BEAR RIVER MIGRATORY BIRD REFUGE, UTAH

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INTRODUCTION

The Bear River Migratory Bird Refuge is situated in northern Utah where it holds an important position as part of the refuge system administered by the U. S. Fish and Wildlife Service. Its geographical position is such that it is influenced by birds of both the Central and Pacific Flyways. To gain more information concerning the migrations of the birds and to more clearly establish the position of the Refuge in relation to them, a comprehensive banding program was initiated in 1929.

In addition to the broad objective of determining migration routes, distributions, and general information, there was a management objective in this banding program. Knowledge of migration routes of the various species is important in their management because measures initiated in one flyway or route may not be applicable to the same species in another flyway. Thus, despite administrative problems, it is particularly desirable to base regulatory measures on conditions in the individual flyways.

Alexander Wetmore, then Research Biologist of the Biological Survey, was sent to the Bear River Marsh in 1914, 1915 and 1916 to study the waterfowl malady known at that time as "Western Duck Sickness." During the course of this work he had opportunity to band and release a considerable number of ducks and other birds. In his report (1923) Wetmore wrote. "Of the 1,241 birds that were banded, 182 returns have been received, or somewhat more than 14 per cent." On the basis of these returns, Wetmore interpreted possible migration routes and made other observations which will be referred to later.

The "Western Duck Sickness" was later determined to be botulism, usually occurring during the warmer summer months. During the botulism season it is the practice to make daily "pick-ups" of sick and dead birds. The dead birds are destroyed and the sick birds hospitalized. Hospitalization for mildly affected birds may involve only protection and providing available food and fresh water, but helpless or prostrate birds are given additional aid with peritoneal injections of anti-toxin. When sufficiently recovered to be released, the birds are banded. Thus, in addition to providing the usual banding information, the program yields evidence on the fate of birds which have apparently recovered from botulism. The main deviations from this source of birds for banding are the trapping of healthy ducks, especially Redheads, early in the history of the Refuge, and the banding of healthy Canada Geese.

Acknowledgement is made to Refuge Clerk Ross H. Norr, W. F. Kubichek of the Section of Visual Information, and the many Refuge and Research employees of the Fish and Wildlife Service who have assisted with the banding program.

BANDING DATA

The following tables and brief discussions include compiled data as taken from the records. The term "return" is used in this paper to include the term "recovery." Use of "recovery," as recorded by bird banders, might confuse the reader because of our frequent references to recoveries from botulism.

Table 1 lists all birds banded from 1929 to July 1, 1948, and indicates the number of returns for each species.

Table 2 lists species for which there were returns, and includes the locations of the band recoveries.

TABLE 1.—BIRDS BANDED AT BEAR RIVER MIGRATORY BIRD REFUGE

Species	1929–1942	1943	1944	1945	1946	1947	Total Banded	Returns to Date
Canada Goose*	2,645	1		14	582	569	3,811	909
Mallard	1,360	12	63	27	100	18	1,580	220
Baldpate	556	29	67	97	79	72	900	65
Green-winged Teal	9,519	93	401	33	141	6	10,193	465
Pintail	9,878	370	922	526	551	24	12,271	639
Gadwall	233	1	8	8	3	48	301	31
Shoveller	877	23	35	59	48	45	1,087	89
Redhead*	3,230		7	5	2	50	3,294	519
Cinnamon Teal	537	2	4		7	32	582	12
Blue-winged Teal						5	5	
Ruddy	30			1	4	37	72	2
Canvasback	4						4	
Golden-eye	1						1	
Lesser Scaup	5						5	1
Amer. Merganser	1						1	1
Whistling Swan	2						2	
American Coot	171				9	41	221	5
California Gull	101						101	
Brewster's Egret	98					3	101	1
Phalarope	6						6	
L. B. Dowitcher	12						12	
Black Tern	4						4	
Black-n. Stilt	28					14	42	
Sandpiper	24						24	
Killdeer	9				7	16	32	
Western Willet	18				3		21	
Treganza's Heron	19						19	3
B. C. Night Heron	24					3	27	
W. F. Glossy Ibis	31					3	34	
Avocet	52				24	4	80	
Marbled Godwit	13						13	
White Pelican	5						5	
Franklin's Gull	12						12	
Pied-billed Grebe	5						5	
Western Grebe	48						48	2
Eared Grebe	166						166	
Marsh Hawk	4						4	
L. B. Curlew	16						16	1
D. C. Cormorant	22					36	58	2
Sanderling	10						10	
Red-shafted Flicker					1		1	
Totals	29,776	531	1,507	770	1,561	1,026	35,171	2,967

Percentage of returns on birds banded at Bear River Refuge—8.44%.
* Banded as healthy birds. Others listed were predominately botulism recoveries.

Table 3 is a record of birds banded elsewhere and checked through the Bear River Station. The 61 returns of this type were from areas also included in the list of locations returning bands attached by this station.

Table 4 is for the primary purpose of recording longevity, or the time interval between time of banding and the time of recovery. A less accurate picture could have been made by making an over-all average; however, the use of a first-year return and a seventh-year return to make an average of a three-year time interval would not present a satisfactory or true picture. Put in another way, the two records noted of ducks having evaded hunters for 11 and 13 years is quite remarkable, while those same two records could have been absorbed in an average involving the total of 2,967 returns with little notice. Available longevity records from other stations indicate great variability and give a basis for the assumption that it is not outstanding that 58% of the returns should be first-year returns, even though the national average on first-year returns may approximate 70% based on analyses made to date.

While the banding program is based predominantly on birds which have re-

TABLE 2.—SUMMARY OF RETURNS BY STATES AND SPECIES ON BIRDS BANDED AT BEAR RIVER REFUGE, 1929 TO 1948

State in Which Recovered	Canada Goose	Mallard	Baldpate	G. W. Teal	Pintail	Gadwall	Shoveller	Redhead	Cin. Teal	Ruddy	L. Scaup	Coot	Brew. Egret	T. Heron	W. Grebe	Long-b. Curlew	Cormorant	American Merganser	Totals
Alabama					2			1											1
Arkansas																			2
Arizona	15	1	2	12	10		3	9											52
California	24	5	20	238	134	4	14	50	3	1		2			2				497
Colorado		4		3	8			51											66
Idaho	37	30	3		4	1		19						1					95
Illinois		1			1														2
Iowa		2		2	2														6
Kansas				1	6			3											10
Louisiana				2	12														14
Maryland								2											2
Michigan								3											3
Minnesota				1	4			5											10
Missouri				2	1														3
Montana	2	3		3	1	1		9	1										20
Nevada	3	3	2	4	3	1		21		1									38
Nebraska		2	1		3		1	11											18
New Mexico		1		3	3	1	2	14											24
North Dakota					4			4											8
Ohio								1											1
Oklahoma		1		1	5			8											15
Oregon		1		1				4											6
South Dakota	1				5		1	4											11
Tennessee					1														1
Texas			1	3	76	1	6	48											135
Utah	815	151	33	176	275	20	58	189	5		1	3	1	1			2	1	1,731
Wisconsin				1															1
Wyoming		7						39											46
Washington					2			1											3
Alaska			1	2	6														9
Canada	12	8	1	9	38	1	1	8											78
Mexico			1	1	31	1	3	15	3					1		1			57
Honduras					1														1
Palmyra Is. T.H.					1														1
Totals	909	220	65	465	639	31	89	519	12	2	1	5	1	3	2	1	2	1	2,967

TABLE 3.—RECORD OF BIRDS BANDED ELSEWHERE AND CHECKED THROUGH BEAR RIVER REFUGE BANDING STATION, 1929 TO 1948

Where Banded	Species	Number	Totals
California:			
San Diego Zoo	Pintail	6	
Ceres	Green-winged Teal	1	
Irvington	Pintail	3	
Rosamond	Pintail	1	
	Green-winged Teal	1	
	undetermined	1	
Piedmont	Pintail	1	
Tulare Lake	Pintail	2	16
Idaho:			
Twin Falls	Mallard	1	1
Kansas:			
Ellinwood	Pintail	3	
	Green-winged Teal	1	4
Louisiana:			
Avery Island	Mallard	1	
	Pintail	4	
	Ring-necked duck	1	
	undetermined	4	10
Montana:			
Medicine Lake Refuge	Pintail	3	3
North Dakota:			
Des Lacs Refuge	Pintail	1	1
Oklahoma:			
Tulsa	Pintail	1	
Harrah	undetermined	1	2
Oregon:			
Malheur Refuge	Gadwall	2	
	Mallard	1	
	Pintail	4	
	Green-winged Teal	1	8
Texas:			
Midland	Pintail	1	1
Canada:			
Swan Lake, B.C.	Green-winged Teal	1	
Many Island Lake, Alta.	Pintail	2	
	Canvasback	1	
Stirling Lake, Alberta	Shoveller	1	
Piff River, B.C.	Green-winged Teal	1	
Imperial, Alberta	Pintail	1	
Mountain Lake, Sask.	Pintail	1	
undetermined	Mallard	3	
	Shoveller	2	
	Pintail	1	
	undetermined	1	15
	Total		61

covered from botulism, the present compilation combines figures on healthy as well as recovered birds. However, for the purpose of distinction it should be noted that over 90% of the Redheads banded were healthy juveniles

TABLE 4.—TIME INTERVAL BETWEEN BANDING AND RECOVERY, BY SPECIES, 1929 TO JULY 1, 1948

Species	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.	7th yr.	8th yr.	9th yr.	10th yr.	11th yr.	12th yr.	13th yr.	Total Return	Per Cent Returns
Western Grebe	1		1											2	4.4
D. C. Cormorant	1								1					2	9
Treganza Heron	3													3	16
Brewster's Egret	1													1	1
Canada Goose	497	173	83	73	37	33	5	7	1					909	23.9
Mallard	145	35	13	18	3	3	1	2						220	14
Gadwall	19	6	1	3	1				1					31	10.3
Baldpate	39	12	6	4	2	1		1						65	7.2
Pintail	299	146	72	53	29	16	12	7	2	1	1	1		639	5.2
Green-w. Teal	209	135	60	24	19	10	7		1					465	4.6
Cinnamon Teal	6	5			1									12	2
Shoveller	55	22	3	3	5			1						89	8.2
Redhead	444	43	18	6	2	3					1	1	1	519	15.7
Lesser Scaup	1													1	20
Ruddy	2													2	3
Am. Merganser		1												1	100
American Coot	5													5	2.3
Long-b. Curlew		1												1	6
Totals	1727	579	257	184	99	66	25	18	6	1	2	2	1	2967	
Interval Percentages	58	20	8.7	6	3.3	2.2	1								
Overall percentage of returns															8.44

on which there are 16% returns. For comparison, the figures on Mallards indicate that the majority of them were banded as adult botulism birds, with a return rate of 14%. However, the comparison does not recognize the difference in the years involved and the resultant inequality in hunting pressure.

The remaining tables and maps give further information on the separate species and are self-explanatory. The years indicated are for the purpose of showing the time interval between the time of banding and recovery. On the maps, the dark spots indicate first-year returns, while the open circles mark other than first-year returns. To prevent overcrowding, a single spot may represent one or more returns.

Common Canada Goose

The Branch of Wildlife Research banded most of the geese listed in the course of a special study on management of the species. The banding was done at a time when the young geese were not yet able to fly, and the mature geese were in moult. In the broad study of Canada Geese, the research activities were not confined

TABLE 5.—RECORD OF COMMON CANADA GOOSE RETURNS
Number banded 3,811, Number of Returns 909, Percentage of returns 23.9%

Location	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.	7th yr.	8th yr.	9th yr.	Total
Arizona	11		1		2		1			15
California	14	2	2	1	4	1				24
Idaho	11	18	5	3						37
Montana		2								2
Nevada		2		1						3
S. Dakota		1								1
Utah	461	139	74	67	30	32	4	7	1	815
Canada		9	1	1	1					12
Totals	497	173	83	73	37	33	5	7	1	909

to the Refuge, much of the work being done in other states of the region. This tabulation includes returns on geese banded and released on the Bear River Refuge only, and does not include returns from geese banded here but

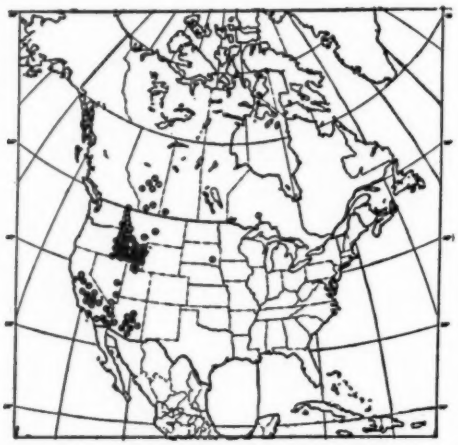

FIG. 1.—Map showing distribution of returns on Canada geese banded at Bear River Migratory Bird Refuge, Utah.

which have been shipped elsewhere as transplants in an experimental restocking program.

The records indicate several interesting examples of geese tending to stay together. Of four geese banded July 7, 1939, two were shot September 20, 1940, and two were shot the following day at Castor, Alberta, Canada. Another goose, probably of the same flock, but banded a few days later, was taken with the others. Four geese banded July 5, 1940 were taken in December 1940 near Camp Verde, Arizona. Three geese, banded on the same date, 7-7-39, were all retaken at Bear River Refuge on the same day, 6-21-48, nine years later.

The records indicate a distribution extending from Canada to California and Arizona, yet almost 90% of the returns are from Utah. The probable reason is that these geese can be considered as being almost year-round residents. The number remaining through the winter depends upon the severity of the season.

Mallard

Mallards are not present in the abundance reached by Pintails and Green-winged Teal during the botulism season, and for that reason fewer Mallards are banded.

Next to Utah, Idaho furnishes the greatest number of Mallard returns. The comparatively large number of first-year returns from that state suggests a post-breeding northward migration. A tabulation of Idaho first-year returns follows:

Date banded	*Date taken*
Sept. 10, 1935	Nov. 23, 1935
July 10, 1929	Oct. 1, 1929
June 25, 1934	Nov. 11, 1934
July 2, 1934	Oct. 21, 1934
July 2, 1934	Oct. 14, 1934
July 9, 1934	Oct. 13, 1934
July 23, 1934	Oct. 6, 1934
July 27, 1934	Oct. 7, 1934
Aug. 4, 1934	Oct. 7, 1934
Aug. 31, 1939	Dec. 2, 1939
Sept. 11, 1939	Nov. 1939
June 22, 1940	Fall 1940
Aug. 28, 1941	*Mar. 25, 1942
Aug. 25, 1944	Nov. 23, 1944

*Caught in muskrat trap.

Note that of the Mallard returns from Idaho, one was taken in March, one in the "fall," one in December, nine in October, and nineteen in November. These data clearly indicate a post-breeding northward movement from the Refuge into Idaho; large numbers of ducks remain on open bodies of water

there during mild weather, but in the case of an extreme winter they move south.

At least one of the Montana records indicates a late northward migration. The Mallard was banded in September and taken November 30 of the same year.

Wetmore secured one record from Bishop, in Owens Valley, California on October 16 but hesitated to claim an early migration because the record was a two-year one. Subsequent records show that at least two Mallards; one banded July 6, 1934 and taken October 21, 1934; and one banded July 27, 1934 and taken October 19, 1934, prove the existence of a migration into California. The Refuge books have no record of a Mallard having been taken in Texas except the one received by Wetmore; however, the records from Oklahoma, Colorado and New Mexico indicate a movement in that direction.

Other records include two Mallards banded June 25, 1934, one of which was taken November 11, 1934 in Idaho, and the other November 30,1934 in Arizona. Two others, banded June 27, 1934, were taken in Colorado and Nebraska October 1, 1934 and November 1, 1934.

FIG. 2.—Map showing distribution of returns on Mallards banded at Bear River Migratory Refuge, Utah.

Idaho and Oklahoma reported Mallards taken in November of 1939 which had been banded here September 11 of the same year.

TABLE 6.—RECORD OF MALLARD RETURNS
Number banded 1,580, Number of Returns 220, Percentage of Returns 14%

Location	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.	7th yr.	8th yr.	Total
Arizona	1								1
California	2	1	1	1					5
Colorado	2	2							4
Idaho	15	6	4	4	1				30
Illinois	1								1
Iowa	2								2
Montana	1	2							3
Nebraska	2								2
Nevada	1		1				1		3
N. Mexico	1								1
Oklahoma	1								1
Oregon		1							1
Utah	111	18	4	12	2	2		2	151
Wyoming	4	2	1						7
Canada	1	3	2	1		1			8
Totals	145	35	13	18	3	3	1	2	220

Two Mallards, taken November 1, 1934 in neighboring towns in Nebraska, were banded at this station June 27 and 29, 1934. Two others, banded

FIG. 3.—Map showing distribution of returns on Gadwall banded at Bear River Migratory Bird Refuge, Utah.

August 10, 1934, were taken in neighboring towns in Wyoming October 14 and 17 of the same year. The two Iowa records were banded July 25 and 27, 1934.

Longevity records include one Mallard which was taken in Nevada six years after banding and one taken on the Refuge where it had been banded seven years before.

Gadwall

Wetmore banded 17 Gadwalls, from which he received four returns. He states that since the returns were from the immediate vicinity of the Refuge and of only short time intervals, they were not significant. The table and map show more widespread distribution and more extensive time intervals. Altogether, the distribution presents a pattern within the Central and Pacific Flyways. The first-year returns from California, New Mexico and Mexico are evidence of this.

The only Texas Gadwall recovery was made November 25, 1937, or four years after banding. Another, banded the same day, was taken October 1, 1933 in Montana. Another Gadwall was taken near this station on November 3, 1943, or eight years from the time of banding.

Of two ducks banded August 4, 1932, one was taken December 9, 1932 in New Mexico and the other was taken December 13, 1932, in Mexico.

TABLE 7.—RECORD OF RETURNS ON GADWALL
Number banded 301, Number of Returns 31, Percentage of returns 10.3%

Location	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.	7th yr.	8th yr.	9th yr.	Total
California	4									4
Idaho		1								1
Montana	1									1
Nevada		1								1
N. Mexico	1									1
Texas					1					1
Utah	12	3	1	3					1	20
Canada		1								1
Mexico	1									1
Totals	19	6	1	3	1				1	31

Baldpate

First-year returns yield data that more certainly determine migration routes. These dates on the Baldpate suggest that soon after leaving Bear River some of them go into Southern Idaho, Nevada, and California.

The first-year returns from Idaho were on birds taken in October and November. The returns from Nevada were for the months of November and December, while the first-year returns from California were taken during November, December and January. Subsequent Baldpate returns from that state include only the months of November and December.

The foregoing lends credence to the idea that one migration route may extend from Bear River into Idaho, Nevada, and eventually to California where most of the birds winter. That some of the Baldpates remain to winter in Idaho is indicated by the record of on having been recovered there in March.

The determination of routes is based on records of the time of the year as well as locations in which the returns were taken. For example, Utah returns include three from December. However, the returns from October far outnumber those from other months; this simply indicates that there were more Baldpates present during that month. Later records from Idaho, Nevada and California indicate their presence there at that time. The fact that most of the records were of the same season aids in determining migration routes.

FIG. 4.—Map showing distribution of returns on Baldpates banded at Bear River Migratory Refuge, Utah.

Some unusual records are cited in the returns from Alaska, Nebraska and

TABLE 8.—RECORD OF BALDPATE RETURNS
Number banded 900, Number of Returns 65, Percentage of Returns 7.22%

Location	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.	7th yr.	8th yr.	Total
Arizona		2							2
California	12	3	2	2	1				20
Idaho	2	1							1
Nebraska								1	1
Nevada	2								2
Texas		1							1
Utah	23	4	3	2		1			3
Alaska			1						1
Canada					1				1
Mexico		1							1
Totals	39	12	6	4	2	1		1	65

Canada. Note that the single Nebraska record had been at liberty for seven years after its recovery from botulism. The Baldpate taken in Canada was shot in Saskatchewan September 29, four years after banding. The Alaska return was also taken in September, two years after banding. Of two Baldpates banded at Bear River September 27, 1945, one was shot at San Diego, California January 2, 1946 and the other was taken January 6, 1946 at the same place. One Baldpate, banded September 27, 1937, was taken November 29, 1938 in Arizona, and another, banded the day before, was taken December 1, 1938 in Texas.

Pintail

The importance of the Pintail in this area is indicated by the hunting records which show that, except for two of the past fifteen years, this duck was the one most commonly checked through this station. The Pintail also shows exceptionally wide distribution.

Interesting records include one bird which was shot on this Refuge, where it was banded ten years before. Another bird, banded at Bear River, was caught in a muskrat trap in Canada eight years after banding. Golovin, Alaska reported a Pintail taken May 5, 1943 which had been banded July 9, 1934. Another was taken in California eleven years after banding.

Cartwright (1945) has noted "'. . . some very early southern migrations, particularly of male Pintails.'

TABLE 9.—RECORD OF PINTAIL RETURNS
Number banded 12,271, Number of Returns 639, Percentage of Returns 5.2%

Location	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.	7th yr.	8th yr.	9th yr.	10th yr.	11th yr.	12th yr.	Total
Arizona	4	1	2		1		2						10
Arkansas		1			1								2
California	58	33	17	8	10	1	5	1				1	134
Colorado	3	3		1	1								8
Idaho	2	2											4
Illinois	1												1
Iowa			1	1									2
Kansas	2	1	1	2									6
Louisiana	3	3	5	1									12
Minnesota	1	2	1										4
Missouri				1									1
Montana				1									1
Nebraska		1		2									3
Nevada	1	1	1										3
New Mexico	2	1											3
N. Dakota		1	2		1								4
Oklahoma	1	3				1							5
S. Dakota	1	2		2									5
Tennessee	1												1
Texas	31	23	7	5	3	4	1	1	1				76
Utah	168	44	21	22	11	4	2	2			1		275
Washington	1	1											2
Alaska		3		1	1					1			6
Canada	3	14	9	4		5	1	2					38
Honduras	1												1
Mexico	14	6	5	2	—	1	1	1	1				31
Palmyra Is., T.H.	1												1
Totals	299	146	72	53	29	16	12	7	2	1	1	1	639

One Pintail, banded at this station in 1929, flew into a wire in Canada May 2, 1930. This record indicates the early presence in Canada of Pintails from this station and suggests that the southerly migration of male Pintails observed by Cartwright could have contributed to the spectacular influx of male Pintails to Bear River each year during the months of June, July and August.

It should be noted that from Canada there were only three first-year returns, as compared with 14 taken between one and two years after banding. The reverse is true in the case of Mexico which had 14 first-year returns, with six returns in the one-to-two year interval. This is to be expected, and serves as evidence that no great northward migration takes place within a short time after the spring migration or the usual time of banding. On the other hand, an example of a moderate post-breeding northward movement is that of a Pintail banded here on September 25, 1940 and retaken in Idaho November 6, 1940. Another Pintail, banded August 28, 1944, was taken November 11, 1944 at Bath, Illinois.

A record which already has received some publicity is that of a Pintail carrying band No. 40–693910, banded August 15, 1942, and found exhausted November 5, 1942 at Palmyra Island, T. H. This duck had flown at least 3,600 miles in the 83 days between the time of banding and the time it was picked up in an exhausted condition.

Wetmore, in his banding work at Bear River during 1914, 1915 and 1916, banded 221 Pintails, from which there were 34 returns. The returns were from locations also included in the present list. Because of the large number of

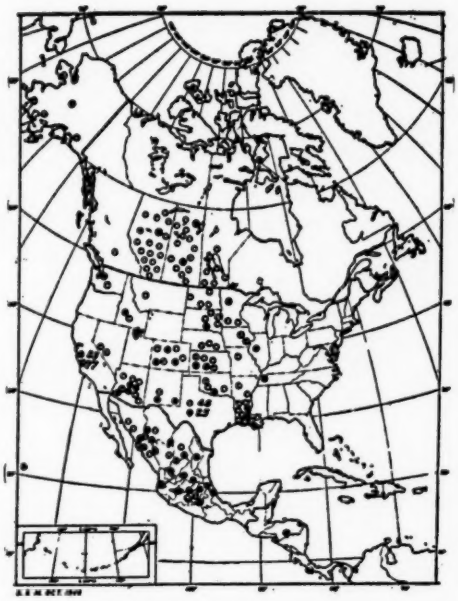

FIG. 5.—Map showing distribution of returns on Pintails banded at Bear River Migratory Bird Refuge, Utah.

birds banded since that time, it is to be expected that returns since Wetmore's work should show greater distribution.

Green-winged Teal

The tabulation and map show the numerous Green-winged Teal returns from California. It is not uncommon for them to be banded at Bear River in September and shot in California in October. The concentrations shown are partly due to the fact that 45 were shot at Gustine, and 48 were taken at Los Banos, California. Many of these teal, banded at the same time, were taken a few months later on the same date.

One Alaska return is noteworthy in that the teal was banded at Bear River September 11, 1933, and shot at Sidney Ridge, Alaska April 28, 1934. It should be noted that of the Canada returns

three were taken during the spring (one of these was caught in a muskrat trap). Green-winged Teal arrive at Bear River during March and April and leave a short time later, probably contributing to the early population in Canada.

FIG. 6.—Map showing distribution of returns on Green-winged Teal banded at Bear River Migratory Bird Refuge, Utah.

It is unusual for the Green-winged Teal to nest in this area; however, two nests were found in the season of 1946. It is significant that for the 1946 hunting season the Green-winged Teal was the duck most commonly found in the bags.

Wetmore reports that of 336 teal banded here, 49 returns were received. Locations contributing to the list of returns, in addition to Utah, were California, Arizona and Colorado. Again, the returns were in line with present return data, except that as greater numbers of birds are banded, greater distribution is found.

Cinnamon Teal

The small number and rate of returns is accounted for, in part, by the fact that the Cinnamon Teal is not abundant on the Refuge during the hunting season. It is usual that when birds are hunted on the same area in which they

TABLE 10.—RECORD OF GREEN-WINGED TEAL RETURNS
Number banded 10,193, Number of Returns 465, Percentage of Returns 4.6%

Location	1st. yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.	7th yr.	8th yr.	9th yr.	Total
Arizona	10	1		1						12
California	75	85	41	16	9	6	5		1	238
Colorado	2		1							3
Iowa		1			1					2
Kansas		1								1
Louisiana	1	1								2
Minnesota			1							1
Missouri		2								2
Montana		2				1				3
Nevada		2	1			1				4
N. Mexico	3									3
Oklahoma	1									1
Oregon		1								1
Texas	1		1		1					3
Utah	114	34	12	7	7	1	1			176
Wisconsin							1			1
Alaska	1				1					2
Mexico		1								1
Canada	1	4	3			1				9
Totals	209	135	60	24	19	10	7		1	465

were banded a higher percentage of returns results.

The areas included in the table substantiate the prediction of early workers that subsequent banding would show a route from this station to California. Not included is a Texas return reported by Wetmore indicating a route to that state. The records place the Cinnamon Teal among the ducks using the more common routes of this region.

The single Montana record was of a bird found dead July 24, 1940, four years after it was banded as a botulism bird. The Mexico records were taken in November, January, and February.

FIG. 7.—Map showing distribution of returns on Cinnamon Teal banded at Bear River Migratory Bird Refuge, Utah.

TABLE 11.—RECORD OF CINNAMON TEAL RETURNS

Number banded 582, Number of Returns 12, Percentage of Returns 2%

Location	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	Total
California		3				3
Montana					1	1
Utah	4	1				5
Mexico	2	1				3
Totals	6	5			1	12

Shoveller

Wetmore received one return from California which suggested that some of the Shovellers winter there. The present report lists 14 returns in support of that suggestion.

It may be significant that the California returns were earlier in the fall migration than those from Arizona, New Mexico, Texas and Mexico. The

TABLE 12.—RECORD OF SHOVELLER RETURNS

Number banded 1,087, Number of Returns 89, Percentage of Returns 8.2%

Location	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.	7th yr.	8th yr.	Total
Arizona	2	1							3
California	4	5		1	3			1	14
Nebraska				1					1
New Mexico	1				1				2
S. Dakota		1							1
Texas	1	4			1				6
Utah	45	10	2	1					58
Canada		1							1
Mexico	2		1						3
Totals	55	22	3	3	5			1	89

FIG. 8.—Map showing distribution of returns on Shovellers banded at Bear River Migratory Bird Refuge, Utah.

California returns included one in October, seven in November, four in December, one in February, and one was undetermined. The Texas returns were taken between November 20 and December 31, and were recovered more than one year from the time of banding. The date pattern may be only coincidental, but it suggests the possibility of a west-east migration route from California to Texas during the winter season. This seems the more credible because of the absence of returns from Colorado, Oklahoma or other intervening states on the Central Flyway.

Interesting records include two Shovellers banded at Bear River September 8, 1933. One of them was taken November 1, 1933 in Los Angeles County, California, and the other was taken November 20, 1934 at Tivoli, Texas. Of three birds banded September 2, 1933, one was taken March 14, 1934 in Mexico very near the Texas coast, one was found April 20, 1937 in Nebraska, and the other was taken December 23, 1934 in Texas.

Other significant Shoveller records concern three ducks banded September 15, 1929. One of them was taken November 15, 1933; one was taken October 16, 1929; and the other was taken November 20, 1930. All three ducks were shot in Imperial Valley, California.

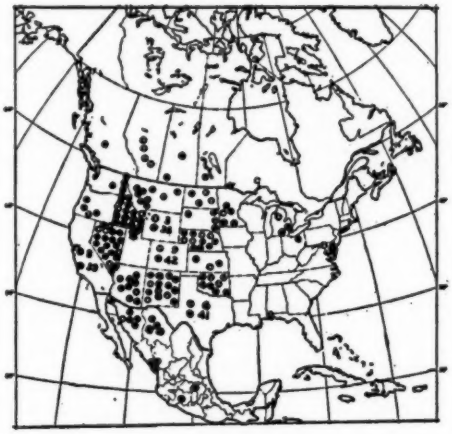

FIG. 9.—Map showing distribution of returns on Redheads banded at Bear River Migratory Bird Refuge, Utah.

Redhead

Twenty-two states and two foreign countries are represented in the list of areas contributing returns on Redheads.

The table and map indicate a dispersal which gives the impression of widespread scattering; yet the distribution still appears to favor the geographical flyway pattern as outlined by Lincoln. As with other species from Bear River, the wintering grounds are shown as being located mainly in common winter positions on the Pacific and Central Flyways.

Two other longevity records, in addition to the one from Maryland, are

from this Refuge. A-607-184, banded July 21, 1929, was shot during the season of 1941. Another Redhead, tagged with band No. A-651-335 July 31, 1930 was shot during the season of 1941.

Wetmore's report of 1923 shows that of the 51 Redhead returns he received, three were from Idaho, one from Colorado, one from Kansas, one from Texas, and one from Arizona. The remaining 44 returns were from Utah.

TABLE 13.—RECORD OF REDHEAD RETURNS
Number banded 3,294, Number of Returns 519, Percentage of Returns 15.7%

Location	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.	7th yr.	8th yr.	9th yr.	10th yr.	11th yr.	12th yr.	13th yr.	Total
Alabama		1												1
Arizona	6	2				1								9
California	40	3	5	1		1								50
Colorado	42	6	3											51
Idaho	17	2												19
Kansas	2	1												3
Maryland			1								1			2
Michigan	2	1												3
Minnesota	3	2												5
Montana	8	1												9
Nebraska	7	3	1											11
Nevada	17	2	1	1										21
N. Mexico	10	2	1	1										14
N. Dakota	2	2												4
Ohio	1													1
Oklahoma	5	2	1											8
Oregon	3		1											4
S. Dakota	3			1										4
Texas	42	3	2	1										48
Utah	182	4	1									1	1	189
Washington	1													1
Wyoming	36	1	1			1								39
Canada	3	4			1									8
Mexico	12	1		1	1									15
Totals	444	43	18	6	2	3					1	1	1	519

There are several records indicating that Redheads are gregarious. One example concerns two ducks banded August 5, 1929 and shot September 16, 1929 at neighboring towns in Nebraska. Two Redheads banded July 24, 1929 were taken October 13, 1929 near Wendell, Idaho, and three birds banded August 4, 1933 were shot October 8, 1933 near Fallon, Nevada. There are many other similar records for these ducks, most of which were banded as healthy juveniles by A. V. Hull.

Miscellaneous

Miscellaneous species are charted together because the few returns listed for them do not justify separate tables. Significant or unusual returns will be noted below.

The Ruddy Duck is quite abundant at Bear River during migration, but relatively few remain to nest. The first-year returns from California and Nevada probably establish the contribution of the Refuge to the winter popula-

tion of Ruddy ducks on the Pacific coast.

The Lesser Scaup record was taken near the Refuge, and it is not particularly significant. Few Scaup are banded here because they are absent from the area during the botulism season.

The migration route of the Coot is important, because this bird is abundant on the Refuge during the summer. If it should become necessary, management of the species could best be carried on in California during the regular hunting season since Coots migrate from Bear River to that state before the local hunting season. The two records from California, taken in November and January, indicate that area as the wintering grounds.

TABLE 14.—RECORD OF RETURNS ON MISCELLANEOUS SPECIES BANDED AT BEAR RIVER REFUGE

Species Location	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.	7th yr.	8th yr.	9th yr.	Total Returns	Number Banded
Western Grebe											48
California	1		1							2	
D. C. Cormorant											
Utah	1								1	2	58
Treganza's Heron											19
Idaho	1									1	
Utah	1									1	
Mexico	1									1	
Totals	3									3	
Brewster's Egret											101
Utah	1									1	
Lesser Scaup											5
Utah	1									1	
Ruddy											72
California	1									1	
Nevada	1									1	
Totals	2									2	
Amer. Merganser											1
Utah		1								1	
American Coot											221
California	2									2	
Utah	3									3	
Totals	5									5	
Long-billed Curlew											16
Mexico		1								1	

The Brewster's Egret was taken approximately 80 miles south of this station on October 30, 1929, three months after it was banded. Wetmore reported returns from Arizona and Mexico.

The Treganza's Heron taken from Utah was banded September 8, 1936

and recovered November 3, 1936. The Idaho record is not conclusive because the heron was found dead. However, its presence there is in line with the traditional heron northward movement. The heron reported from Mexico was banded at Bear River May 23, 1933, and taken in Sonora January 16, 1934.

The Western Grebe returns are fortunate because the habits of these birds are such that a live bird carrying a band would not be readily noticed. Ducks and other birds are hunted and trapped, but grebes are not shot for sport, and they are seldom seen in flight. The two returns from California were saved from anonymity by being found dead. Both Grebes were banded at Bear River in June, 1934. One was picked up at Santa Cruz, California December 15, 1936 and the other was found March 30, 1935 at Carpenteria. The Western Grebe arrives in this area early in the spring, becomes abundant in May, and, according to the returns, it winters in California.

The Long-billed Curlew, a common nester at Bear River, evidently finds its way to Mexico where it winters. The sole Curlew return was from a bird banded at this station June 11, 1929 and recovered near Ensenada, Lower California, on September 18, 1930.

The interesting Double-crested Cormorant, also a common nester in Utah, is not a year-round resident, and it is unfortunate that the only returns are local returns. The seven-year record would be more valuable if more information had been given with the return. Often, belated returns are sent concerning birds which may have died years before.

The American Merganser record is of some interest because it was taken in a distant part of the state and during the succeeding season. This does not necessarily prove a migration, because mergansers occasionally winter in Utah.

SUMMARY AND DISCUSSION

The Bear River Migratory Bird Refuge is situated in northern Utah where it is affected by birds of the Central and Pacific Flyways. It was established mainly as a measure to control the prevalent duck sickness and to provide sustenance for the populations of migrating waterfowl.

There have been 2,967 returns on the 35,171 birds banded from 1929 to 1948. Fifty-eight per cent of the returns were from birds which had been at liberty for less than one year, as compared with a possible national figure of approximately 70 per cent. For the most part, the routes used by the birds are within the areas covered by the Central and Pacific Flyways. Location, species, hunting, time of banding, and other factors enter into the ratio or percentage of returns. Wetmore, in his banding activities at Bear River, received returns of over 14 per cent, while the present program lists 8.44 per cent. Probably changes involving the factors mentioned have had effect.

Sick birds picked up for treatment for botulism constitute the main source of birds for banding. This report makes few distinctions between affected birds and healthy birds, but with little exception the work can be described as having been based on birds which have recovered from botulism. It may be questioned that such a program could be considered representative of a normal banding program, and it has been

suggested that these birds may prove more vulnerable to attacks of parasites and other diseases. However, it should be noted that there are few "repeats" in the daily pickup of sick and dead birds, and the analysis of the returns indicates a gratifying survival rate.

It is desirable that there should be more data for comparing return figures on botulism ducks with returns on healthy birds; however, the figures on Redheads and Mallards may be used to indicate a similarity of results. There were returns of 15.7 per cent on the former, which were banded as healthy birds, while there were returns on 14 per cent of the Mallards which, for the most part, were botulism birds. Figures based on comparative returns of the same species banded at similar times would be more conclusive.

In addition to providing general banding information, the program strongly suggests that birds once recovered from botulism are not unduly vulnerable to subsequent disease or repeat attacks, but make normal migrations and provide impressive longevity records.

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STUDIES ON THE DEVELOPMENT, GROWTH AND MATURITY OF THE CHAIN PICKEREL, *ESOX NIGER* LESUEUR

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In eastern United States, especially the northeastern portion, the Chain Pickerel, *Esox niger* LeSueur, is of considerable importance, both as a game fish and in its relationship to other species. It is hoped that the present paper may give fisheries' managers in this area some additional data on which to base policies.

The material was collected in the course of studies at Cornell University and is incorporated in a thesis submitted to that university in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Literature Review

There is a great deal of literature published on this species, but articles on subjects within the scope of this paper are somewhat limited. Ayers (1843) reports a 14-pound, 38-inch *reticulatus* from the Hockanum River near Hartford, Connecticut, and a 20-pound specimen taken in the spring of 1842 near Greenfield, Massachusetts. There is little question in this writer's opinion that these large fish were *Esox lucius*.

Storer (1867, p. 311) reports he has seen specimens from Cape Cod up to 7 pounds. "This fine species is the common pickerel of Massachusetts . . . , and is everywhere valued."

The report of the Massachusetts Fish Commissioners (1870) indicates growth varies with temperature and gives the following figures for some hundred examined in a cold spring-fed pond with plenty of food:

1 year, 4½ inches, ½ ounce; 2 years, 7 inches, 1½ ounces; 3 years, 10 inches, 4 ounces; 4 years, 13½–14½ inches, 8–12 ounces; 5 years, 17½ inches, 24 ounces; 6 years, 20 inches, 40 ounces.

In a large, warm pond covered with lilies and full of young alewives, pickerel reached 4 to 5 pounds in 3 years.

The American Naturalist (1871) records the following note on growth:

"This fish, like all bad characters, makes a worse show the more he is studied. Dr. E. L. Sturtevant investigated their powers of eating in the following manner. He put 2 young pickerel about 5 inches long, in a trough with a great quantity of little minnows of about one inch in length; and these two pickerel ate 128 minnows the first day; 132 the second; and 150 the third! and they increased one inch in length in 48 hours! They were mere machines for the assimilation of other organisms! Fifth Report of Massachusetts Commissioners of Inland Fisheries, 1871."

Goode (1884) lists pickerel fairly high as a food fish, states it reaches a weight of 7 or 8 pounds, but is usually smaller. Bean (1891) gives length up to 2 feet—occasionally 8 pounds (much above average). "A fierce and hungry marauder." Spawning in winter and early spring, young soon become solitary and wolfish like adults.

Raney (1942) made a summer study

of pickerel (*E. niger*) in a 9-acre New York pond. He gives the following table on size of young:

Total Length of 119 Pickerel Young of the Year

Date Captured	*Mean T.L. mm.*	*Range mm.*	*N*
16 June 1939	40.5	32– 66	8
24 June 1939	47.7	42– 58	7
30 June 1939	39.2	30– 50	38
28 July 1939	65.1	60– 76	27
2 August 1939	67.6	58– 77	9
21 August 1939	93.0	73– 96	8
31 August 1939	95.8	80–113	14
22 September 1939	90.6	81–119	8

Foote and Blake (1945) found no significant difference in growth between males and females caught in a 200-acre Connecticut bog pond, but their fish were all small, mostly between 9 and 13 inches. In 1940, 351 out of 359 taken were under 15 inches and 550 out of 600 in 1941 were under 16 inches.

McClane (1947) points out that the former Field and Stream record (10 pounds, 10 ounces) for *E. niger* has been disallowed as the fish proved to be *E. lucius*. He states any pickerel 7 pounds or over will be a record.

Introduction to Original Data

The majority of the original data for this paper were collected between September 1936 and September 1940. The study was concentrated on bodies of water thought to be representative of pickerel habitat, at least in the northeast if not over its whole range. Supplementary data were collected from a wide area. The three principal study areas were Papish or Glover's Pond near Cincinnatus, New York; the south end of Skaneateles Lake near Scott, New York; and Willseyville Creek at Willseyville, New York.

Papish Pond is a brown water, muck bottom pond of approximately 35 acres; it reaches a maximum depth of about 20 feet. The shoreline vegetation is composed largely of alder, shadbush, swamp rose, huckelberry, buttonbush, leather leaf, etc., which are in or over the water in a fairly advanced stage of plant succession. There is no inlet other than springs in the bottom, and there is a small dam across the outlet. The fish present are: common bullhead, *Ameiurus nebulosus nebulosus;* golden shiner, *Notemigonus crysoleucas;* chub sucker, *Erimyzon oblongus oblongus;* chain pickerel, *Esox niger;* yellow perch, *Perca flavescens;* common sunfish, *Lepomis gibbosus;* and a few introduced largemouth black bass, *Micropterus salmoides.*

Skaneateles is one of New York's Finger Lakes. It is about 30 miles long by one to two miles wide and reaches a depth of several hundred feet. It contains many species of fish, but those of importance to anglers are: Rainbow trout, *Salmo gairdnerii irideus;* Lake trout, *Cristivomer namaycush namaycush;* Brown trout, *Salmo trutta fario;* Smallmouthed black bass, *Micropterus dolomieu dolomieu;* Pickerel, *Esox niger,* Perch, *Perca flavescens;* Bullheads, *Ameiurus nebulosus nebulosus;* and Rock bass, *Ambloplites rupestris rupestris.* The pickerel habitat is largely restricted to the southern end where silt from the inlet stream has formed a shallow area (varying in depth from a few inches to 15 or 20 feet) extending a mile or more into the lake. This shallow portion contains many weedbeds and adjoins a cattail marsh at its southern end. The inlet flows through this marsh, which, together with surrounding fields, is often flooded in the spring.

Willseyville Creek is a tributary of

Catatonk Creek which flows into the Susquehanna River. It flows principally through meadowland or pasture, is about 18 miles long, partially fed by springs, and contains many ponds created by man or beaver. The banks are often swampy, and much land is flooded in the spring. The stream is of borderline temperatures for trout and is rich in fish species. There are some rock riffs, but on the whole it is slow-moving with much aquatic and emergent vegetation.

DEVELOPMENT AND RATE OF GROWTH OF YOUNG PICKEREL

In central New York *Esox niger* usually spawns during the month of April. The eggs require from six to twelve days to hatch, the length of time required being largely governed by the water temperature. The sac fry are able to swim as soon as hatched but if undisturbed are relatively inactive. They lie on their sides on the bottom or attach themselves to submerged debris or aquatic vegetation. No detailed study was made of the mechanics of this attaching. The young pickerel probably have a gummy secretion similar to that described by Embody (1918) for *Esox lucius*. Plate 14, A, shows a fry attached to aquatic vegetation. The point of contact was the most anterior portion of the head, and they apparently were able to fasten and unfasten themselves at will.

New-hatched sac fry from artificially impregnated eggs all sank to the bottom when first placed in an aquarium. During the first half hour a few swam up and attached themselves to the sides or to vegetation, but the majority remained motionless on the bottom. After dark most of these swam up and fastened themselves to the sides, vegetation, or surface film. In general, the six different lots of fry observed in aquaria exhibited the same behavior. At night approximately 75 per cent of them were up off the bottom and attached, the other 25 per cent were lying on their sides; during daylight the reverse was true—about 75 per cent being on the bottom and the remainder attached. The same results could be obtained by darkening or lighting the aquaria.

Naturally-spawned, wild pickerel sac fry were observed on numerous occasions. During daylight none was observed attached. They lay on their sides on the bottom among the grass roots, debris, and silt. When disturbed, they swam rapidly several inches usually ending by trying to burrow into the roots or debris. On two occasions wild fry were observed at night; many were attached to grass stems and other vegetation. When exposed to bright light for several minutes, most, but not all, would swim to the bottom. No wild fry were seen adhering to the surface film although this was quite common in the aquarium.

Six to eight days are required for the absorption of the yolk sac. By the time this is accomplished, the mouth is formed and feeding commences almost at once. Until the yolk is completely absorbed, the fry lie on their sides on the bottom except when moving or attached. When the yolk is gone, they move up off the bottom, lie upright in the water and commence feeding. From the very first their behavior is characteristic of the genus. The tiny pickerel lie motionless among the grass and sub-

merged vegetation, darting out to capture any suitable food which comes within their range of vision. At this size nearly any form of animal life small enough to be swallowed is taken if available.

Eighteen newly-hatched fry from 4 different lots of artificially impregnated eggs were measured with calipers to nearest ½ millimeter. Their length was remarkably constant; the mean was 6.1 mm. with a standard deviation of .19 mm., well within the limit of mechanical accuracy. The mean T.L. of 14 fry (6 wild and 8 from the 4 lots of artificially-impregnated eggs mentioned above) measured as the yolk was absorbed and feeding commenced was 10.2 ± .32 mm.

Spawning usually occurs in swampy, marshy, or flooded areas. As a rule these situations are very fertile and rich in insects, crustacea, fish fry, and other aquatic forms on which the young pickerel feed. While growth varies in different bodies of water, it is generally rapid. Table 1 records chronologically the sizes of pickerel fry from various locations. The rapidity of growth is quite apparent, but it is felt that the samples of the populations from the three primary locations do not justify any conclusions of a differential rate. While there seems to be some variation at certain ages, it shifts over the summer and is not considered significant.

Comparison between the growth of these fry and those recorded by Raney (loc. cit.) is difficult because of different

TABLE 1.—SIZE OF YOUNG PICKEREL OF VARIOUS AGES FROM DIFFERENT BODIES OF WATER

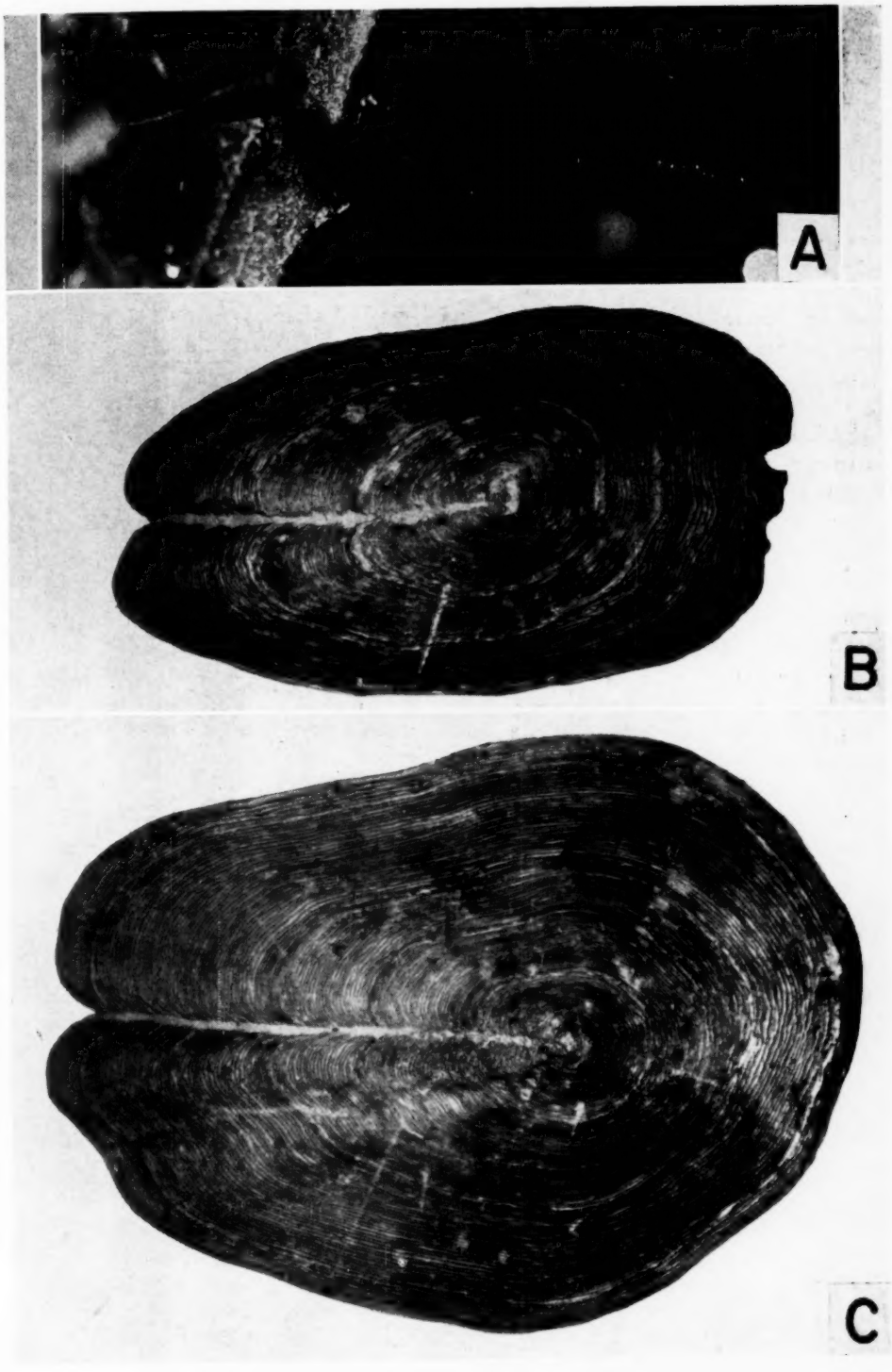
Date	Approx. Age in Months	Willseyville Creek		Papish Pond		Skaneateles Lake		Myosotis Pond*		Lincoln Pond*	
		TL cms	N	TL cms	N	TL cms	N	TL cms	N	TL cms	N
7 July, 1937	2+							5.7 ± .98	31**		
18 July, 1937	2½+									5.35 ± .54	28**
	14 mo.									10.1	1**
20 July, 1937	2½+							6.0 ± .99	2**		
14 May, 1939	½	1.05 ± .009	6								
7 June, 1939	1½	2.7 ± .73	9								
	1			3.4 ± .26	4						
30 Oct. 1939	6+	14.9 ± 1.7	3								
30 Nov. 1939	7+	17.1 ± 1.6	23								
15 Apr. 1940	12	18.5 ± 1.5	14								
30 May. 1940	1+	1.9 ± .29	3								
9 June 1940	1					2.85 ± .28	37				
6 July, 1940	2½	5.3 ± .7	18								
12 Aug. 1940	3			5.97 ± .5	14						
	3					6.42 ± 1.4	8				
24 Aug. 1940	3½			7.22 ± .64	9						
25 Aug. 1940	4	7.94 ± 1.0	6								

* Albany County.
** Collected by Dr. W. J. Hamilton Jr.

PLATE 14. A. Newly hatched pickerel fry attached to vegetation in aquarium. Normal position is hanging vertically from under side of leaf.

B. Scale of four-year-old male pickerel, captured, tagged and released 27 April, 1939, Papish Pond. TL, 41.6 cm.; SL, 35.9 cms.; Wt., 350 gms. Photo. by A. L. Smith.

C. Scale taken May 2, 1940 from same male pickerel shown in B. TL, 45.1 cms SL, 39.4 cms.; Wt., 484 gms. Note growth during fifth growing season. Photo by A. L. Smith.


A
B
C

years and different bodies of water, but, in general, growth is similar.

RATE OF GROWTH OF ADULTS

It is felt that the rate of growth of mature pickerel can best be presented by the accompanying tables and graphs. A brief word pointing out the aims of the study and a short discussion of the methods used should suffice.

Data have been collected from three separate bodies of water. On the basis of growth rate it is desirable to show whether or not the pickerel captured in these situations were samples drawn from a single or different populations. Secondly, if there is any sexual dimorphism, it should be demonstrated.

Age was determined by scale reading. In some instances the annuli were very distinct and easily read; in others it was much more difficult. However, for the most part it is felt the readings are accurate. All age determination was checked on at least two scales and in some cases as many as ten were examined. It was found that the most readable scales came from a region just above the lateral line between anal and dorsal fins. Due to the rather extensive lateral line system of the pickerel, care must be taken to avoid using scales bearing lateral line pores.

An examination of Tables 2, 3, and 4

TABLE 2.—AGE-LENGTH SUMMARY OF PICKEREL CAPTURED FROM WILLSEYVILLE CREEK

Date	Male		Female	
	Total Length cms.	N	Total Length cms.	N
	Age I			
Spring 1939	18.2 ±2.0	5	19.5 ±1.8	2
Fall 1939	17.2 ±2.0	11	16.8 ±1.4	9
Spring 1940	17.7 ±1.4	8	19.3 ±1.2	4
	Age II			
Spring 1937	23.9 ±3.4	8	27.3 ±1.95	6
Spring 1939	25.8 ±2.9	15	28.4 ±3.1	8
Fall 1939	24.4	1	27.9	1
Spring 1940	30.0 ±2.2	4	29.9 ±3.5	4
	Age III			
Spring 1937	30.6 ±1.5	2	30.7 ±1.7	2
Spring 1939	31.3 ±4.4	3	30.2 ± .7	3
Fall 1939			36.2 ±3.4	2
Spring 1940	34.3 ±1.46	8	36.9 ±1.77	9
	Age IV			
Spring 1940	35.7 ±3.3	3		
	Age V			
Spring 1940	40.4 ± .14	2		
	Age VI			
Spring 1940			52.0	1

TABLE 3.—AGE-LENGTH SUMMARY OF PICKEREL CAPTURED FROM PAPISH POND

Date	Male		Female	
	Total Length cms.	N	Total Length cms.	N
	Age II			
Winter 1936–37			25.8	1
Fall 1937			30.7	1
Spring 1940	27.6 ±4.0	2	27.0 ±1.4	2
	Age III			
Winter 1936–37	31.6	1		
Fall 1937			40.6	1
Fall 1938			39.8 ±7.9	2
Spring 1939	33.3 ±5.7	9		
Fall 1939			37.8 ± .7	2
Spring 1940	32.3 ±5.5	5	34.1 ±6.6	5
	Age IV			
Winter 1936–37	33.9 ±2.3	4	39.9 ±2.3	4
Fall 1937	42.6	1	52.6	1
Fall 1938	40.5 ±1.4	2		
Spring 1939	39.4 ±3.8	9	40.0 ±6.8	4
Fall 1939	43.2	1		
Spring 1940	39.3 ±4.3	14	42.6 ±4.6	13
	Age V			
Winter 1936–37	42.8	1	37.9	1
Spring 1939	41.4 ±2.4	8	44.5 ±6.5	4
Spring 1940	44.9 ±2.4	5	52.3 ±1.5	4
	Age VI			
Spring 1939	44.3	1	43.6 ±3.7	3
	Age VII			
Spring 1939			53.4	1

will reveal the great variability in length shown by specimens of the same age and sex taken in the same body of water. This variability makes it difficult to demonstrate significant differences with the size samples we have available despite the several trends which seem to be apparent.

Five three-year-old fish of each sex from each location captured in the spring were run through an analysis of variance. When more than five specimens were available in any category, five were selected at random by the use of cards. The lengths were transformed to logarithms for this treatment since this reduces the range without altering the relationship of the means. The results of this treatment were as follows:

Source of Variation	*DF*	*Sum of Squares*	*Mean Square*
Total	29	.092	
Error in Subclasses	24	.043	.00179
Location	2	.047	.0235
Sex	1	.001	.001
Interact Sex × Location	2	.001	.0005

This indicates that there is a significant difference in total length of fish of the same age from different locations, but does not demonstrate a significant difference between the sexes.

Feeling that there really was a significant size difference between sexes, especially in the older fish, the writer applied analysis of variance to four specimens of each sex 3, 4, and 5 years old. Willseyville was excluded from this treatment as the older fish were not available. Again specimens were selected at random when there were more than four from which to draw. The results of this treatment were as follows:

Source of Variation	*DF*	*Sum of Squares*	*Mean Square*
Total	47	.210	
Error in Subclasses	36	.039	.00108
Location	1	.055	.055
Sex	1	.0245	.0245
Age	2	.0865	.04325
Interact Sex × Age	2	.060	.030
Interact Sex × Location	1	.0915	.0915
Interact Age × Location	2	.0295	.01475
Interact Sex × Age × Location	2	.005	.0025

Using total length as the criterion, this indicates significant differences between locations, between sexes, and between ages. The interactions of sex × age, sex × location, and age × location are also significant, indicating greater sexual dimorphism with increasing age, vary-

TABLE 4.—AGE-LENGTH SUMMARY OF PICKEREL CAPTURED FROM SKANEATELES LAKE

Date	Male		Female	
	Total Length cms.	N	Total Length cms.	N
	Age I			
Spring 1940	18	1		
	Age II			
Spring 1939	35.1 ± 2.1	3	37.3 ± 2.4	2
Spring 1940	33.2	1	39.3 ± 1.3	2
	Age III			
Spring 1939	39.9 ± 4.0	3	41.4 ± 2.4	4
Spring 1940	44.4 ± 1.1		48.5	1
	Age IV			
Spring 1939	48.3	1	50.2 ± .9	2
Spring 1940	48.0 ± 3.9	5	51.4 ± .6	2
	Age V			
Spring 1939	49.0	1	55.5 ± 2.8	3
Spring 1940	52.7	1	54.2	1
	Age VI			
Spring 1939	51.1 ± 4.5	2		
Spring 1940	50.5	1		

ing sexual dimorphism in the two different locations, and varying age growths in the two locations. Based on the results of these two treatments and on the trends which can be noticed in

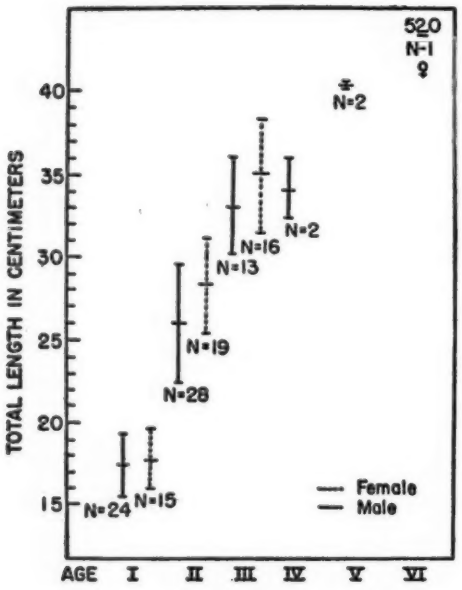


FIG. 1. Mean total length and standard deviation of pickerel from Willseyville Creek.

figures 1, 2 and 3, the writer feels justified in concluding that on the basis of rate of growth the sample fish from the three locations being studied are not drawn from the same population but from three separate populations. On the same basis, it is felt that there is a real difference in growth between sexes, especially in the older fish, the females growing more rapidly than the males.

An interesting side line on the growth of pickerel in Papish Pond is furnished by the data in Table 5 on tagged fish. On 10 May, 1939, when the nets were withdrawn, there were 34 tagged pickerel at liberty in the pond. Five of these fish, still bearing tags, were recaptured between January and May 1940. The growth of these individual fish is shown below. During their fifth growing season, the two males and one female exhibited a growth below the mean based on scale reading (the IV's of 1939 to the V's of 1940, see Table III). However, the growth of the tagged three-year-old

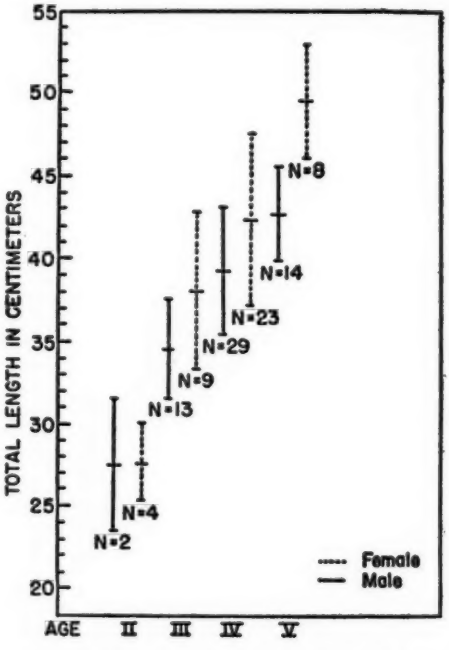


FIG. 2. Mean total length and standard deviation of pickerel from Papish Pond.

males of 1939 closely approximates that of all the three-year-old males.

The scales of these five fish show very nicely the growth of the intervening year and the formation of the additional annulus. (See Plate 14, B and C). The tag used was forced through the flesh of the caudal peduncle just in front of the caudal fin and fastened by bending the two prongs.

Between 26 April and 10 May, 1939, three fish were caught which had already lost their tags; they were retagged and liberated, but this gave early evidence that the type of tag used would not prove successful. Fish which have lost the tag, of course, cannot be identified as individuals, but they can be recognized as recaptures since the scar at the spot of tagging is readily discernible for a period of at least a year after the tag is lost. During the period of January to May 1940, seven fish so scarred were taken (one four-year-old male, one five-year-old male, and five five-year-old females), bringing the recapture figure to 12 out of 34. It is not possible to use these figures to derive any kind of a population estimate, but they do indicate a low population among the older fish. Out of nine three-year-old males tagged in 1939, four were recaptured as IV's in 1940 and out of seven four-year-old females, six were recaptured the next year.

The oldest pickerel taken in this

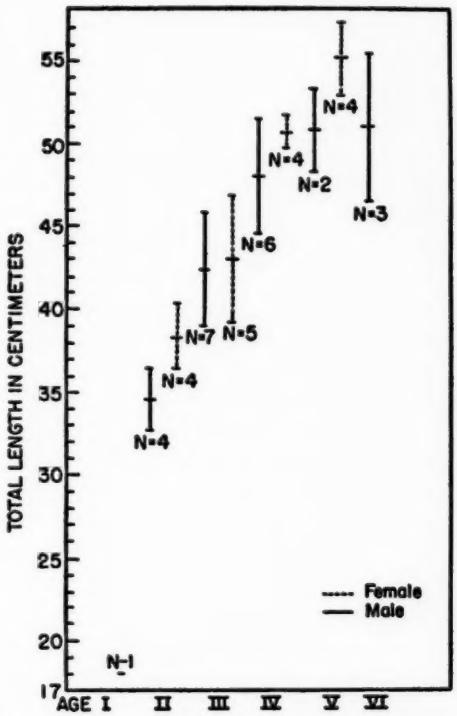


FIG. 3. Mean total length and standard deviation of pickerel from Skaneateles Lake.

TABLE 5.—RETURNS FROM TAGGED PICKEREL IN PAPISH POND

Initial Capture						
Date	Sex	TL cms.	SL cms.	ST grams	Number of Annuli (Age)	
3 May, 1939	Female	47.2	40.7	600	IV	
28 Apr., 1939	Male	33.7	29.2		IV	
1 May, 1939	Male	32.7	28.2	195	III	
26 Apr., 1939	Male	32.8	28.3	200	III	
27 Apr., 1939	Male	41.6	35.9	350	IV	

		Recapture				Gain	
Date	Sex	TL cms.	SL cms.	Wt grams	Number of Annuli (Age)	TL cms.	Wt grams
2 Jan., 1940	Female	50.5	40.5	750	V	3.3	150
29 Mar., 1940	Male	37.6	32.4	312	V	3.9	
23 Feb., 1940	Male	41.3	36.3	425	IV	8.6	230
2 May, 1940	Male	39.6	34.4	336	IV	6.8	136
2 May, 1940	Male	45.1	39.4	484	V	3.5	134

study were seven years old: a female from Papish Pond, 53.5 cms. total length (about 21 inches), weighing 1,000 grams (about 2 pounds, 3 ounces), and a male from Skaneateles Lake of 50.5 cms. total length and 966 grams. The largest fish from the three main study areas were a 54.0-cm., 1,075-gram, 6-year-old female from Papish Pond; a 52.0-cm., 875-gram, 6-year-old female from Willseyville; and a 55.4-cm., 1,099-gram, 5-year-old female and a 55.5-cm., 961-gram, 6-year-old male from Skaneateles Lake. The largest fish examined was a 58.4-cm., 1,389-gram (3 pound, one ounce) female in the middle of her fifth summer taken angling by Dr. Wm. J. Hamilton, Jr., in Myosotis Lake, Albany County, New York.

None of these fish is a particularly large pickerel. Four to five-pounders are quite often taken in many localities. For a number of years Field and Stream listed a 10-pound, 10-ounce pickerel as the world record. Due to the confusion of common names and accurate identification, it was only recently discovered that this fish came from a section of Canada where *Esox niger* does not occur and was probably a pike or walleye.

The two largest pickerel on which the writer has any accurate data were taken in Sullivan County, New York. The data on these fish were furnished by Clayton B. Seagears, Director of Conservation Education, N. Y. S. Conservation Department. As far as can be ascertained from verified information, these are record pickerel. Both weighed 6 pounds, 8 ounces. One was taken by James Brown on 15 May, 1936 in Pleasure Lake, Fallsburgh, New York (Sullivan County) and was 28 inches long. The other was taken by Howard Lundstrom in Lake Muskoday, also Sullivan County on 27 December, 1936. This fish was weighed by Mr. Seagears personally on city-tested scales 14 hours after capture, and weighed exactly 6 pounds, 8 ounces.

MATURITY

Of 15 one-year-old females taken at Willseyville from the end of October through the breeding season, three were mature. The mean total length of the mature females was 18.8 ± 1.9 cms.; the mean total length of the immature females was 17.2 ± 1.72 cms. This size difference is not significant when judged by the "t" test.

Of 24 one-year-old males taken under the same conditions, 12 were mature. The mean TL of the mature males was 18.5 ± 1.54 cms.; of the immature males, 16.2 ± 1.28 cms. This difference is also not significant when judged by the "t" test.

Of 14 two-year-old females, 12 were mature. Their mean length was 29.1 ± 2.97. The two immature two-year-olds had a mean of 19.3 ± 1.414. This size difference is significant and indicates that either very slow growth retards maturity or that some other factor or factors may retard both rate of growth and development of maturity.

Fifteen out of 18 two-year-old males were mature. Their mean length was 25.5 ± 3.9 as opposed to 22.4 ± 2.52 for the immature two-year-old males. This size difference is not significant. Thirteen three-year-old females were taken; all were mature and all 14 of the three-year-old males taken were mature.

Of 105 pickerel (42 females and 63 males) taken in Papish Pond just prior

to and during the spawning seasons of 1939 and 1940, only three immature fish were taken. In March 1939 an immature three-year-old male was taken. This fish had made very poor growth being only 21.1 cms. as compared to the three-year-old male mean of 34.5 ± 3.0. On 27 May, 1940 another three-year-old immature male was taken. His length was 24.5, also well below the mean. The other immature fish was a two-year-old female (26.0) taken in May, 1940.

Only four two-year-old fish were taken. These were: a ripe male (30.6 cms.) and a spent male (24.5 cms.) taken in May, 1940, a spent female (28.0 cms.) also May 1940, and the immature female mentioned above.

Table 6 records the mature pickerel taken in Papish Pond during 1939 and 1940.

TABLE 6.—MATURE PICKEREL TAKEN FROM PAPISH POND

Age	Sex	1939	1940
II	Male	0	2
II	Female	0	1
III	Male	9	5
III	Female	0	5
IV	Male	11	13
IV	Female	7	16
V	Male	10	8
V	Female	4	6
VI	Male	2	0
VI	Female	3	0
VII	Male	0	0
VII	Female	1	0

Sixty-six of these fish were taken during the spawning season in a fyke net set off the principal spawning grounds. The remaining 39 were taken in fyke and gill nets scattered over the pond. Twenty-five of these fish were taken during February and March before movement to the spawning grounds commenced. During spawning only 14 fish were taken at other locations although 2 gill and 1 fyke nets were fished continuously at various points about the pond. It is thus felt that the age composition of spawning fish is fairly accurate. Most three-year-old males spawning, some three-year-old females, and all females and males spawning the fourth year. It is felt that very few two-year-old fish, either male or female, spawn in Papish Pond.

In Skaneateles Lake 8 two-year-olds were taken, 4 of each sex. Of these only one male and one female were immature. Judging from these specimens, size was not a contributing factor as the immature male was the largest of the four and the immature female was well above the mean for the four females. All the older fish taken were mature. The single one-year fish taken was an immature male. The sample of fish taken from the Skaneateles spawning grounds was composed of: I—1 male; II—4 males, 4 females (3 of each mature); III—7 males, 4 females; IV—6 males, 5 females; V—2 males, 4 females; VI—3 males.

It will be seen that the age of development of sexual maturity seemed to differ in the three study locations. At Willseyville a few one-year-old females and about half the one-year-old males were mature. Practically all two-year-old fish were mature. No immature three-year-olds were captured. The age composition of spawning fish showed that the bulk of the spawning population was composed of 2 and 3-year-olds. In Papish Pond it was found that most three-year-old males and some three-year-old females spawned; all four-year-old fish were mature; but very few

two-year-old fish spawned in Papish Pond. The age-frequency indicated that the bulk of the spawning population was composed of four and five-year-old fish. In Skaneateles Lake 3 out of 4 two-year-old pickerel of each sex were mature. The immature fish were larger than the mature. All older fish taken were mature. No one-year-old fish were found in the spawning population. The sample from here was small, but fish from two to five formed the bulk of the spawning population with three and four-year-olds occurring most frequently.

MATURITY AND LEGAL SIZE

At Willseyville most of the females had spawned once and many of the males twice before they reached the legal size of 12 inches. In this stream pickerel are the most important sport fish; their growth rate is comparatively slow. The present legal size limit is about right to assure maximum utilization of the fishery and also its preservation. In Papish Pond legal size for both sexes was attained during the third growing season. The data collected, especially age composition of the spawning populations, indicated that while some three-year-old fish spawned, most fish spawned for the first time when four years old. The present legal size limit should be increased to at least 14 inches to allow one spawning season before reaching legal size. This is especially true if a proper balance is to be maintained between pickerel and the large perch population which is present in the pond. Skaneateles Lake pickerel reached legal size during the second growing season. If they spawned as two-year-olds, they were subject to legal capture for the latter part of the second season. The age composition of spawning fish indicated that most spawned for the first time as three-year-olds. Increasing the size limit to 15 inches would greatly improve pickerel fishing in this lake. It is very doubtful if such a move would injure the rainbow or lake trout fishing.

WEIGHT-LENGTH RELATIONSHIP

The weight of fish at various lengths is a subject which has long interested both fishermen and fisheries' investigators. The relationship between weight and length has been used in various fashions to indicate condition. Workers on trout have evolved a formula to furnish a condition factor "a," where $100W = al^n$. W = weight, l = length, n is a constant 3, and a is condition. This formula has proved fairly satisfactory for trout but when applied to other species has left much to be desired.

Foote and Blake (loc. cit.) give some data on weight-length of *Esox niger* from a Connecticut pond. The following is an excerpt from their Table 3:

	FEMALES		MALES	
Average TL cms.	N	Average Wt. grams	N	Average Wt. grams
29.8	8	212.7	10	193.3
27.8	13	174.7	12	176.3
25.9	18	141.4	14	137.9
23.7	12	98.1	21	117.1
22.0	8	85.0	17	86.9
20.3	4	69.5	11	72.4

These fish are small, and, as is the case with the smaller or younger fish in the present study, there is no significant weight difference between fish of opposite sexes at the same length. Their work indicated a very high population

of small pickerel, but they do not give ages. It is possible that their population is composed of a relatively high proportion of older fish that are stunted in length but run fairly heavy. At any rate, a comparison with the Willseyville Creek pickerel shown in Table 10 (the only population in the present study of comparable lengths) reveals that Connecticut pickerel in the same length groups were much heavier.

Tables 8, 9, and 10 show the weight-length relationship of the three populations being studied. For convenience in recording the data and to allow comparison, they have been grouped into 4 centimeter length classes. An examination of these tables reveals that the weight-length relationship of the same sex size groups from Willseyville Creek and Papish Pond is very close. No significant difference can be detected.

TABLE 7.—WEIGHT-LENGTH REGRESSION COEFFICIENTS OF PICKEREL

Location	Sex	"b" ± Standard Error	N
Skaneateles Lake	Female	3.54 ± .18	12
	Male	3.27 ± .26	17
Papish Pond	Female	3.04 ± .07	56
	Male	3.14 ± .06	61
Willseyville Creek	Female	3.11 ± .11	41
	Male	3.12 ± .04	52

TABLE 8.—WEIGHT-LENGTH RELATIONSHIP OF PICKEREL CAPTURED IN PAPISH POND

Length Class in cms.	Males			Females		
	N	Mean TL and Standard Dev. in cms.	Mean Weight and Standard Dev. in grs.	N	Mean TL and Standard Dev. in cms.	Mean Weight and Standard Dev. in grs.
18.1–22.0	1	21.1	49			
22.1–26.0	2	23.6 ± 1.3	62 ± 6.4	4	25.1 ± 1.0	82 ± 13.7
26.1–30.0				3	27.9 ± 1.0	111 ± 17.0
30.1–34.0	13	32.3 ± 1.1	193 ± 28.4	4	32.4 ± 1.3	209 ± 37
34.1–38.0	7	35.9 ± .7	271 ± 21.4	10	35.9 ± 1.5	282 ± 52.3
38.1–42.0	20	40.4 ± 1.0	378 ± 39	6	39.8 ± 1.0	364 ± 45
42.1–46.0	16	43.5 ± 1.2	463 ± 45	9	43.7 ± .8	519 ± 50
46.1–50.0	2	46.9 ± .7	593 ± 10	12	47.0 ± .7	584 ± 64
50.1–54.0				7	52.7 ± 1.3	828 ± 157
54.1–58.0				1	55.0	837

TABLE 9.—WEIGHT-LENGTH RELATIONSHIP OF PICKEREL CAPTURED IN SKANEATELES LAKE

Length Class in cms.	Males			Females		
	N	Mean TL and Standard Dev. in cms.	Mean Weight and Standard Dev. in grs.	N	Mean TL and Standard Dev. in cms.	Mean Weight and Standard in Dev. grs.
34.1–38.0	1	37.4	317			
38.1–42.0	1	42.0	458	5	39.9 ± 1.4	388 ± 55
42.1–46.0	7	44.2 ± 1.3	532 ± 66			
46.1–50.0	4	48.1 ± 1.2	746 ± 112	2	49.0 ± .7	708 ± 18
50.1–54.0	3	52.2 ± 1.5	983 ± 15	3	51.2 ± .5	973 ± 66
54.1–58.0	1	55.5	961	1	54.2	1065
58.1–62.0				1	58.5	1564

TABLE 10.—WEIGHT-LENGTH RELATIONSHIP OF PICKEREL CAPTURED IN WILLSEYVILLE CREEK

Length Class in cms.	Males			Females		
	N	Mean TL and Standard Dev. in cms.	Mean Weight and Standard Dev. in grs.	N	Mean TL and Standard Dev. in cms.	Mean Weight and Standard Dev. in grs.
14.1–18.0	13	16.4 ± 1.2	23.4 ± 5.2	6	16.8 ± .86	26 ± 4.1
18.1–22.0	11	19.4 ± 1.06	39.4 ± 7.8	7	19.3 ± 1.15	37.4 ± 5.6
22.1–26.0	5	23.8 ± 1.2	68.6 ± 14.9	2	24.4 ± .9	90.5 ± 35.4
26.1–30.0	6	28.1 ± .9	110 ± 12.7	8	27.7 ± 1.0	118 ± 29.7
30.1–34.0	8	32.1 ± .9	183 ± 21.8	7	32.5 ± 1.2	200 ± 43
34.1–38.0	6	35.3 ± .7	268 ± 19.3	5	36.4 ± 1.2	299 ± 50.4
38.1–42.0	3	40.0 ± .8	369 ± 18.2	4	38.6 ± .4	335 ± 23
42.1–46.0						
46.1–50.0						
50.1–54.0				1	52.0	875

However, both the males and females from Skaneateles Lake run heavier than pickerel from the other two locations in the same size groups. The Skaneateles males in groups 42–46, 46-50, and 50–54 and the Skaneateles females in groups 38–42, 46–50, and 50–54 are significantly heavier than those from Papish Pond and Willseyville Creek (only the females in group 38–42 can be compared) when judged by the "t" test. If weight at a given length can be taken as an indicator of condition, the pickerel from Skaneateles Lake were in better condition than those from the other two locations.

If weight and length are converted to logarithms, it becomes a straight line relationship, and the regression coefficient, "b," can be calculated. This statistic measures the slope of the line and can be used to determine whether or not the larger or older fish in one population are gaining more weight at a given length than those in another population. Table 7 gives these regression coefficients and their standard error.

Student's "t" test indicates that there is a significant difference between the females from Skaneateles Lake and those from the other two locations. This is the only significant difference discernible. This further substantiates the conclusion that the fish from Skaneateles Lake gain weight more rapidly than those from the other locations.

SUMMARY

The study was concentrated on three areas thought to be representative of pickerel habitat: a stream, a pond, and a good sized lake, all in central New York. Data collected in these areas were supplemented with material from many locations in eastern America.

Pickerel eggs require from 6 to 12 days to hatch; 6 to 8 days are required for the absorption of the yolk sac.

Eighteen newly-hatched fry measured 6.1 ± .19 mm. total length; the mean total length of 14 fry measured as the yolk was absorbed and feeding commenced was 10.2 ± .32 mm.

Growth of young was rapid but varied so much from season to season and within bodies of water that comparisons of rate between different bodies of water were not judged significant.

Age and total length data are given for 269 adult pickerel. Biometric treatment of this data shows a significant difference in growth rate between the pickerel of the three main study areas. It is also shown that there is a real difference in growth between sexes, especially in the older fish; the females growing more rapidly than the males.

The growth of five tagged pickerel recaptured a year later is included.

The oldest pickerel examined were seven years old; the largest was 1389 grams. Included is a record of two pickerel that weighed 6 lbs. 8 oz. These are thought to be record fish.

The age of development of sexual maturity differed in the three study locations. In the stream a few one-year-old females, about half the one-year-old males and practically all two-year-old fish were mature. Age composition of samples showed the bulk of the spawning population to be composed of two and three-year-olds. In the pond most three-year-old males and a few three-year-old females spawned; all four-year-olds captured were mature. The bulk of the spawning population was made up of four and five-year-old fish. In the lake most two-year-olds captured were mature. The sample was small but fish from two to five formed the bulk of the spawning population with three and four-year-olds occurring most frequently.

In most situations a 12 inch legal size limit is too small. Fish are subject to capture before they have spawned even once. However, the limit set should be determined by the situation in a given body of water.

The weight-length relationships of pickerel from the three study areas are given. It was found that the larger fish from Skaneateles Lake were significantly heavier at a given length than were those from the other two bodies of water.

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BIG GAME MANAGEMENT IN COLORADO

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Introduction

Recent publications, both scientific and popular, have spoken of game and fish resources as big business (Carhart, 1947; Cottam, 1947; Drury, 1947; Gabrielson, 1945; Gillham, 1946). This is one of the truest statements that can be made of big game in Colorado, whether considered from a standpoint of land, people involved, or financial structure.

A little less than one-half of Colorado, or about 46,836 square miles, is *occupied* big-game range, on which this resource must be managed. This is an area larger than either Pennsylvania or Ohio. In 1946, a total of 112,320 big game licenses were sold; in 1947, 99,834; in 1948, 113,362. Thus, an average of more than 108,000 citizens annually, or 10 per cent of the population, seek big game in the state. Big game license sales in Colorado amounted to $1,292,987.25 in 1948.

Obviously, license cost represents only a small fraction of the money turnover involved in harvesting deer, elk, bear, and occasionally antelope in the state. All other costs, on the basis of an extensive survey made by the Colorado Game and Fish Department (Hunter, 1949), were found to be $45.78 per resident hunter, and $114.30 per non-resident hunter. Thus, the total calculated financial turnover was $6,004,415.46 in 1948.

It is the belief of the writers, and of game technicians generally, that, through proper management, big game herds and values can be perpetuated. This statement is far more conservative than the often-made one that game supplies, or indeed any renewable resource, can, through proper management, be made increasingly valuable. Any resource worth one-sixth of a billion dollars in a single state is worthy of the highest form of husbandry, if for no other reason than the money value involved. This paper is, therefore, intended as a contribution to biologically and administratively sound management of the immensely valuable big game resources of the western states.

Acknowledgments

We are indebted, first of all, to the progressive, research-minded Game and Fish Commission of Colorado, whose several members have supported procedures leading to many improvements in administrative and management techniques. Director of the Game and Fish Department, Cleland N. Feast, has likewise encouraged and loyally supported progressive game management operations.

[1] The Colorado Game and Fish Department, the Colorado A & M College, the Wildlife Management Institute, and the U. S. Fish and Wildlife Service, cooperating.

The technical staff of the Department, E. K. Brown, Laurence E. Riordan, Glenn Rogers, Paul Gilbert, A. E. Carlson, Harold R. Shepherd, Donald Lauridson, L. W. Searle, C. D. Tolman, George W. Jones, Robert R. Elliott, and Kenneth Milyard and Norman Kramer, Pilots, made possible studies leading to verification and refinement of techniques. Without their unstinted cooperation, the results reported here could not have been obtained. Jack C. Culbreath, Educational Manager, aided in many ways. Assistant Director John D. Hart assisted with legal, fiscal, and administrative problems; and the Enforcement Division, headed by Chief Warden William Hunn gave invaluable help with checking station, census, and other operations.

Professor J. V. K. Wagar, Head, Department of Forest Recreation and Game Management, Colorado A & M College, kindly read the manuscript and offered constructive suggestions for its improvement.

ORGANIZATION

Game administration in Colorado is achieved through the Game and Fish Commission, a 6-member, governor-appointed body. No political party may be represented by more than 3 members. All members serve staggered 6-year terms, and none may succeed himself. One member of the Commission must be a stockman. The Governor is a member *ex-officio*.

In the organization described, Colorado, as regards responsibility for big game management, is similar to many other states. Of great significance, however, is the friendly and constructive attitude of the Commission to game management activities, and its willingness to accept recommendations made on a factual basis by the Department. This attitude automatically provides the mechanism for achieving progress based on the findings of the technical staff. This operating principle is so important that the writers, in emphasizing it, state frankly that the progress made in big game management in Colorado during recent years is due in great measure to this forward-looking attitude on the part of the Commission.

Staff organization within the Game Management Division consists of seven sections, together with necessary stenographic and clerical assistance. These sections are Federal Aid, Air Surveys, Experimental Lands, Fur Research and Surveys, Cooperative Research, Damage Appraisal and Control, and Economic Evaluation, including a subdivision devoted to statistics and International Business Machine operation.

The basic field organization is represented by a staff of sixteen trained big game biologists, with headquarters at advantageous locations throughout the state. Some of these biologists are carried on Federal Aid funds; others on regular Department funds. It is the findings of these technicians, particularly, that has supplied the basis for our progress in big game management. Correlation of findings, and application to administrative problems, is the responsibility of the senior author, ably assisted by heads of the divisions named above.

One of the points to be considered in developing a technical staff is the variety of skills possessed in the aggregate by such personnel. The 24 men concerned with big game in Colorado in-

clude two expert and several skilled photographers, a qualified game parasitologist, a grazing specialist, several capable range examiners, a literature specialist, and others. All of the biologists are experienced in aerial big game counting; and all, by common necessity, are capable packers, campers, and outdoorsmen. Still greater variety in skills is attained through specialized assignments. For example, the Colorado Department is developing antelope, bighorn sheep, elk, and mule deer specialists, at least from the standpoint of detailed experience with these species. The over-all personnel objective is the development of a staff capable of handling most ordinary, and many unusual, problems likely to arise in big game management.

The technical staff, to be most efficient, requires the assistance of various non-wildlife specialists. Pilots trained in the type of flying required in big game census and surveys, are examples. The need for such personnel is too obvious for further comment. In passing, however, it is not out of place to stress the utility of good mechanics, maintenance crews, and labor. Even a cook can make or break morale in a camp of lengthy duration.

The Department planes are side-by-side Cessnas, 120 and 140, radio equipped. They are available the year around for big game work. Two skilled pilots, experienced in mountain flying, are likewise available the year around. They are assigned to various biologists, or to special joint operations, as need arises. Also available during emergencies or during rush periods is a private plane, manned with a pilot who has had extensive mountain flying experience.

Experimental stations and lands are being acquired. Notable among research areas now in operation is the Little Hills Range Experiment Station, in northwest Colorado. Here, 15,000 acres of typical western Colorado winter range, together with serviceable ranch dwellings and outbuildings, have been acquired for research in population relationships, competition between various big game species and livestock, range restoration, and similar studies. Numerous other experimental tracts are available, but research programs thereon are only now being formulated.

The Colorado Cooperative Wildlife Research Unit, located at Colorado A & M College, Fort Collins, is operated for the joint purpose of training men for technical positions in game management and ecology, and to assist the Department with its game and fish problems. At this writing, the Unit has been in existence nearly two years, and has undertaken two big game, two fur animal, and several farm-game investigations. It promises to be of great help to the Department in conducting research on specific problems and in aiding the technical staff in various ways. In addition, the Unit has supplied the Game and Fish Department with five men who are now on the permanent staff.

In regard to publicity, the Department recognizes its obligation to the public, and strives through both the press and radio, to keep the public accurately informed. All members of the technical staff handle radio assignments in their respective districts. Weekly news releases, following a seasonal sequence, serve to keep sportsmen and others abreast of Department activities, including big game information.

The basic land-unit organization in administration is in the form of 59 big

game districts, embracing all big game range in Colorado. A variable number of districts, depending on game populations and problems, are assigned to each of the 16 biologists, who are responsible for determining population trends, range condition, and other aspects of big game management in their respective localities.

FACTORS AFFECTING BIG GAME MANAGEMENT IN COLORADO

Land area, elevation, use, and ownership profoundly affect big-game management in Colorado. As stated previously, about one-half of the state's area is occupied big game range, a very large part of which is also occupied by sheep and cattle. Extremely high average elevation creates the fundamental problem of ample summer range but critically short winter forage. Most of the summer range is publicly owned, the U. S. Forest Service administering the largest acreage; available winter range is about evenly divided between private interests and the federal Bureau of Land Management.

The foregoing conditions quite understandably set the stage for varied and at times serious conflicts in interests. The greatest competition is between cattle and elk, and sheep and mule deer. Cattlemen, however, are more militantly organized than other livestock groups and offer the greater difficulties in big game administration. Mutual understanding of problems by both groups, particularly the necessity of maintaining the range in productive condition, is resulting in improved relationships between the Department and livestock interests.

Four federal agencies hold administrative control over public land in Colorado. These are the Forest Service, the Bureau of Land Management, the Indian Service, and the National Park Service. The Forest Service controls vast areas of summer range; the Bureau of Land Management about one-half of the winter range suitable to game. National Park land is not extensive by way of comparison, although 524,000 acres are involved. Mesa Verde National Park is almost entirely a winter-use area, while the very much larger Rocky Mountain National Park offers both summer and winter forage, with some overlap in seasonal use by game. Of the several National Monuments, only Dinosaur, in northwest Colorado, is of significance to big game, the value in this case being wintering ground for mule deer. Since the forage produced in National Forest and Bureau of Land Management land is highly important to both livestock and big game, the conflict in interests is instantly apparent. Heaviest sheep use is in northwest, southwest, and southcentral Colorado; cattle use predominates elsewhere.

Vegetation in Colorado, for the most part low and thin, is generally favorable to the use of planes for census and surveys, especially during winter and early spring. Only coniferous forests at high elevations are unsuited to this technique, and since these areas do not serve as wintering grounds, they offer no limiting factor in plane work.

Colorado, like other states, has numerous sportsmen's organizations. These groups, in the main, are not dominated by rabid hunting interests, and for this reason, sportsmen's groups have become a distinct asset to the Department in its efforts to promulgate and administer sound and equitable game seasons and regulations. It is be-

coming apparent that the policy of keeping sportsmen accurately informed, regardless of whether news is good or bad, is winning their confidence. Their support follows as a matter of course. Department personnel, particularly biologists, attend sportsmen's meetings and often assist in programs. Press and radio information, centered on facts and kept as current as possible, is the basic operating principle of the Department's public relations division.

Deer winter primarily on Bureau of Land Management and privately-owned land; elk, largely at lower elevations on Forest Service land. Unfortunately, therefore, both game and livestock use the same range during the same season, thus permitting no alternation that might serve to mitigate this problem.

In Colorado, the shortage of winter range is emphasized by data presented in Table 1.

TABLE 1.—WINTER RANGE PROBLEM IN COLORADO, BY SPECIES AND AREA[1]

By Herds				By Area			
Species	Breeding Population	With Inadequate Winter Range		Species	Total Winter Range, sq. mi.	Inadequate for Winter Herds	
		No.	%			Sq. mi.	%
Deer	274,000	118,100	43	Deer	14,256	6,912	48
Elk	39,400	5,500	14	Elk	4,918	828	17

[1] Deer: Most of Western Slope.
Elk: Mt. Evans and Hermosa herds.

Chambers of Commerce, often guilty of overselling fishing and hunting opportunity, are likewise kept accurately informed in Colorado regarding these resources. As a result, publicity from this source is generally in line with facts. It is to be admitted that some abuse occurs. Dude ranchers who find wildlife a top attraction, strongly support the Department's big game program.

SUMMER *vs.* WINTER RANGE

Without question, the most serious big game problem in Colorado, or in the West, is the severe lack of balance between summer and winter range. This is emphasized by the fact that in Colorado there are only two small areas having a shortage of summer forage, while on the other hand, maintenance of the winter range is the constant and paramount problem of management.

It can be said that the inadequacy of winter range in Colorado, long the reason for spectacular deer die-offs here as elsewhere, has been reduced during recent years. The chief mechanism for effecting such adjustment is seasons which permit does to be hunted. Since 1940, seasons restricted to antlerless animals have been limited by area; no statewide antlerless season was allowed until 1948 when the entire state was thrown open to "hunters' choice" on elk.

In 1949, a deer season permitting two animals per license was allowed on about one-third of the inhabited range, and hunters' choice on all remaining deer range. This is by far the most liberal season ever granted in Colorado.

The usual herd control in Colorado has been through hunters' choice seasons, limited to actual and potential

problem areas, wherein each big game license holder is entitled to one antlered or one antlerless animal, or two antlerless animals. This regulation generally results in the killing of bucks by trophy and by the more experienced hunters; and does by others. Despite a preponderance of females in the normal herd, and the greater ease of hunting them, no deer season in Colorado has yet resulted in the killing of more females than males. Elk hunters, on the other hand, have shown a distinct choice for cows, undoubtedly because of the better quality of the meat.

Another variation in hunting regulations as a means of herd control was initiated in 1948. This was a special *pre-season* on deer in two badly overused areas, with a limit of two deer per license, one of which *must* be antlerless; or, the hunter was permitted to take two antlerless deer. Variation in the length of seasons, post-seasons, and other regulations will be discussed under *Seasons and Limits.*

POLICY AND TECHNIQUES

Big game administration and management policy, and the techniques designed to implement them, are so closely interwoven that it seems desirable to discuss both under a combined heading. Likewise, no attempt is made to consider, or even list, all possible subjects falling into these categories. The discussion will deal only with policies and techniques found particularly useful in Colorado, whether in terms of management results or economy in cost and manpower.

Census

Population determination is probably the most important management responsibility associated with big game. As elsewhere, attempts have been made in Colorado to reduce census to seasonal routine, but very large area and rugged terrain, in addition to large numbers, makes this operation difficult, time-consuming, and costly. As a result, special efforts have been given to the development of census refinements and short cuts.

Four techniques have been used in Colorado in determination of big game populations. These are drives, sample strips, plane counts, and special indices.

Drives.—Conventional driving was the first counting method used. It was early discarded as being too ineffective, time-consuming, and costly under Colorado conditions (McCutchen, 1938; McCain, 1939; Ruff, 1939). Since a minimum of 50 men are required to drive a section with any degree of accuracy, and since hundreds of square miles are necessary to reliable sampling in the state, manpower limitations alone dictated discontinuation of the driving method. Its known inaccuracy under conditions of rugged terrain and heavy vegetation also disqualified it as a satisfactory census technique.

Sample Strips.—Census, or more properly, population estimates, based on sample strips have been extensively developed in Colorado (McCutchen, 1938; Hunter, 1944, 1945, and others). The method involves the conventional transect or plot of known area, a number of which are permanently established in each important unit of the deer range. Elk are censused only by plane. In most instances range appraisal plots are on these sample strips. This arrangement permits the recording of both population and range data at the same time, thus insuring the closest possible degree of efficiency and correlation. In

some cases, qualified wardens make counts; in others, both counts and appraisals are made by biologists. In some cases, the plots are so located as to permit travel by automobile, but many sample areas are reached only by horse or by snowshoe travel.

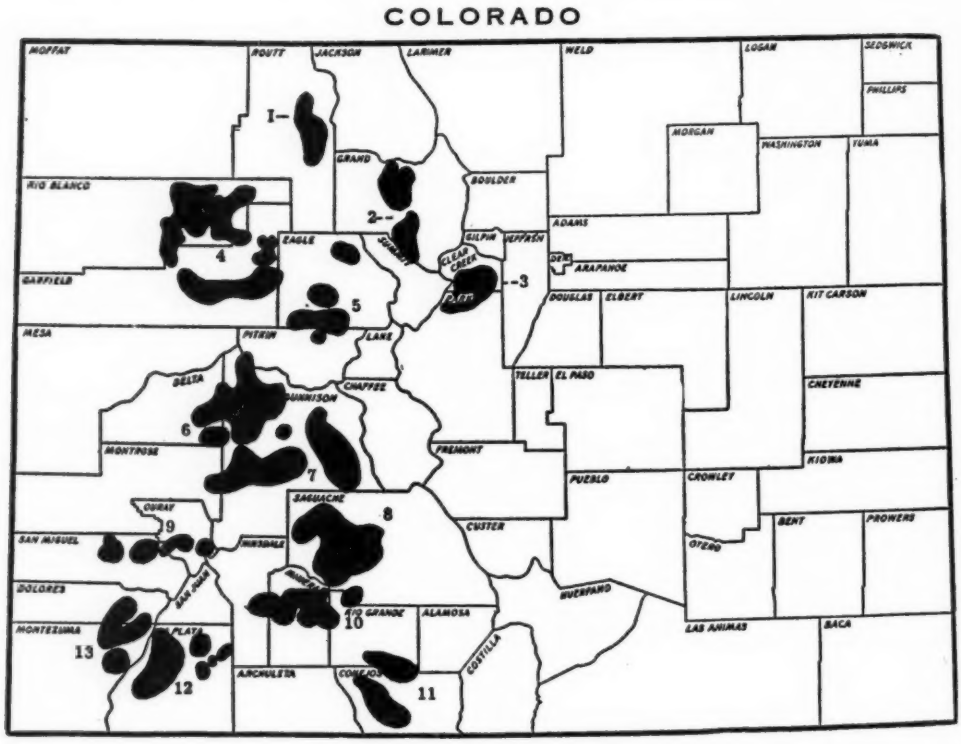

FIG. 1.—Aerial census trend study plots for elk, Colorado. (Six more plots added in 1949.)

Airplane Counts.—Increasing dependence is being placed in the airplane as a tool in censusing Colorado big game. Employing the principle of sample areas, all elk counts, Figure 1, and all counts of deer on inaccessible areas, are by plane. Likewise, nearly all information on antelope and bighorn sheep numbers is being obtained by plane. In 1948, preliminary trials indicated that, under certain conditions, aircraft could be used in estimating bear populations, the most favorable season being Spring before the development of leaves on oak and other hardwood vegetation.

The extent to which planes are used for census purposes is indicated in Table 2.

TABLE 2.—USE OF PLANES IN DEER AND ELK CENSUS IN COLORADO

Species	Number of Flight Routes	Total Range, sq. mi.	Sample Flights, sq. mi.	% of Range
Deer	18	46,836	1,188	3
Elk	19	16,392	3,296	20

The wide discrepancy in the percentage of range of the two species covered is due to the fact that deer generally occur in more accessible territory, and are, therefore, more easily censused by sample strips or special indices than are elk.

Special Indices.—Two techniques, growing out of migration behavior, are now used in Colorado to determine the trend in mule-deer numbers. These are meadow counts along Piceance Creek south of the lower White River, and migration counts along Highway 13, between Rio Blanco and Meeker, a distance of 20 miles.

Meadow Count.—As grass in the Piceance Creek bottom greens up, usually between April 10 and 20, the large Meeker herd of mule deer (normally a browsing species) loiters here to graze for a few days en route to summer range. On April 12 and 13, 1947, 10 men counted 9,878 animals; on April 20 and 21, 1948, a similar crew counted 9,813 animals; and on April 15 and 16, 1949, 9,939 animals; all counts being on the same meadows. The Piceance Creek valley, which runs north and south, intercepts this herd, thus offering favorable conditions for this sort of count. The manpower involved is reduced 12-fold, since it required 240 man-days to make comparable counts at road crossings in the same general locality. Although three years is not sufficient to test such a technique thoroughly, it appears that two important deductions may be based on it, (1) year-to-year trend in herd numbers, and (2) a population index, on which to estimate total herd numbers. The latter is contingent on accurate determination of the percentage of the herd represented by the meadow count, a task partly completed during the springs of 1948 and 1949.

Migration Count.—This technique, first instituted in Colorado by the Forest Service, has been discussed by a number of workers (Carhart, 1943; Ruhl, 1932; Ruff, 1939; Schrader, 1944) and consists essentially of daily counting of separate deer tracks along a given strip or boundary. Such was the procedure followed in the counts on Highway 13 and the Flag Creek road. About 20 miles of the road berms were dragged daily, usually just before dark. The next morning, crews counted the tracks made during the night. It required 3 teams of 2 men each a total of 240 man-days to make the count. Since deer move mostly at night, such a census at a favorable site is accurate and effective, but costs are much higher than in the case of meadow counting. Road counts were made by the Department for 6 years during the period of 1939–1947, and are regarded as one of the most accurate censusing methods employed.

The relative merits of the two techniques may be compared:

Meadow Count

1. Rapid and economical
2. Animals seen, condition judged
3. Adult-fawn ratio can be determined
4. Difficult to determine the exact time to count
5. Required pooling of 10 or more trained men for a 3 or 4-day period (2 days to make counts)

Migration Count

1. Slow and costly
2. Animals not seen, condition not determined
3. No adult-fawn ratio possible
4. Certain, and probably more accurate for total herd
5. Required only 6 men, but for a 40-day period

Sexing

Sex ratio and age-class determination are necessary and at times difficult operations. Despite antlers, which, during late summer, fall, and early winter, permit relatively easy sex and age identification in the deer family, such determinations often tax the skill of technicians when animals must be viewed from a distance or on unfavorable terrain. To insure greater accuracy in identification, the Department now uses planes for nearly all sex and age counts, for which Hunter (1944) and Riordan (1948) described the procedure. In addition to greater accuracy, the cost of air counts is far less than when made by ground crews, as shown in Table 3.

TABLE 3.—COST OF MULE DEER SEX DETERMINATION, PLANE VS. GROUND CREWS

Method	Time Required, hrs.	Number Counted	Cost per Head
Plane (pilot and counter)	37.25	7,919	$0.071[1]
Ground crew	624.0	4,586	0.208

[1] Includes plane rent and pilot's salary.

Trapping and Transplanting

It is the policy of the Department to build up herds and to restock suitable range through the trapping and transplanting of native wild stock (Hunter, 1946; Hunter, Swem and Jones, 1946). Under this system, bighorn sheep, antelope, mountain goats, and wild turkeys are being released on areas meeting habitat requirements.

In the case of mountain goats, there is no positive evidence of former occurrence in the state; stocking in this case is equivalent to introduction. Turkeys were reduced to remnant numbers, but brought back by protection, and later, by transplanting to new localities having suitable habitat. Moose, probably native, were extirpated except for stragglers, and must be reintroduced if they are to be added to the big game fauna of the state. Sheep, antelope, elk and mule deer have never been extirpated from the state. Whitetail deer once occurred in small numbers but apparently are no longer year-around residents. A small migratory herd appears to work north out of New Mexico during the summer, their Colorado range being only in the Sangre de Cristo Range (Hunter, 1948).

The Department also holds to the policy of not transplanting big game to areas unsuited to the species involved, or where breeding stock is already present, or where the establishment of herds will be detrimental to other legitimate prior uses of the area. For these reasons, no further planting of mule deer or elk is now contemplated. The elk range in extreme northwestern Colorado is not fully stocked, but since all elk herds are showing substantial increase in numbers and a steady westward expansion, it is felt that stocking would involve unnecessary expense. There are no appreciable areas of unoccupied mule-deer range in Colorado.

The indications are that moose should be reintroduced in the state. There is little question of suitable range for moose, at least in limited amounts, but there is the possibility of their becoming pestiferous in the event of successful reintroduction and increase. Large herds would offer additional competition to livestock. The problem confronting the Department

is, therefore, one of ultimate value to the people of Colorado and, in the end, to sportsmen, with whose money reintroduction would be effected. This statement is included as an example of an important problem with which western states are often faced, and as an illustration of the Colorado Department's attitude toward it.

Winter Feeding

As was true in other states, Colorado at one time carried on an extensive winter-feeding program (Carhart, 1943; Doman and Rasmussen, 1944). In 1942, the Department was spending $38,000 for winter feeding on the Gunnison area alone, and about $10,000 annually in other areas. At present (1949) prices, this would be equivalent to about $100,000 annually. Despite feeding, 5,000 deer died in the Gunnison area during the winter of 1941–42. In Glenwood Canyon, also in 1941–42, 253 dead animals were found on one 40-acre site; the total was many more. Practically all of the animals died with full stomachs, the food consisting of alfalfa and the concentrate known as "sheep checkers."

In view of these results, all feeding was discountinued in northwestern Colorado in 1943, and in the Gunnison locality one year later. Definite herd improvement has become apparent during succeeding years, and spectacular losses have declined.

During January, February, and March, 1949, unprecedented blizzard conditions prevailed over much of western United States. To meet the contingency induced by this condition, the Colorado Game and Fish Department resumed feeding in a modified form. The primary purpose of this effort was to get additional food to deer and elk in order to reduce depredation on hay stacks. Feeding in this instance was accomplished in cooperation with the U. S. Air Force, and the Air Wing of the Colorado National Guard. C-47 planes were used, each loaded with two tons of first-cutting alfalfa, which was dropped in strategic areas over the western slope. Runs were over exposed ridges above ranches. The bales of hay struck the ground at about 100-yard intervals and invariably broke apart, thus scattering the hay.

It was observed that deer and bighorn sheep would eat some hay and then browse on various shrubs. Antelope would not eat the hay, but continued to drift ahead of the storms to localities that afforded natural food. Elk, of course, consumed the dropped hay freely.

Feeding in this instance achieved a control function. It is believed that the method can be used to advantage in the future to prevent, at least partially, damage to hay stacks and orchards on private holdings.

Experience elsewhere has shown that malnutrition may occur despite the availability of food (Taylor and Hahn, 1947). To maintain health, the food intake in deer and elk apparently must possess certain nutritive, mineral, and probably other qualities; certainly malnutrition, as detected by such tests as bone marrow condition and the absence of body fat, followed by heavy mortality, may occur despite abundance of certain foods.

Parasites and Diseases

In Colorado it has been observed that starvation and high parasitological incidence go together. Parasites, both

external and internal, seem always to be present in greater or less numbers, and only await weakness in the individual animal or herd to become noticeably apparent. There seems to be no doubt that progressively heavy infestations hasten the death of poorly nourished or otherwise weakened animals. In general, healthy, well-fed deer, elk, and other big game are resistant to normal parasitic infestations and seldom show ill effects from them. The Department's basic policy, therefore, in combating parasites and diseases in big game herds is to balance numbers with range condition and otherwise strive to maintain general herd health. Artificial feeding serves to concentrate deer and elk on still smaller units of winter range, thereby aggravating both nutritional and parasitological difficulties.

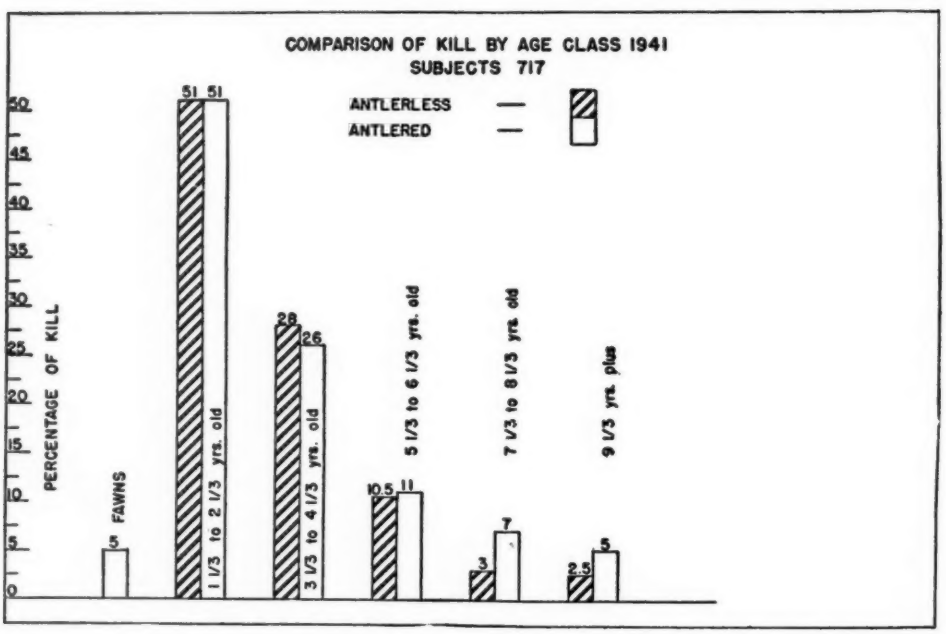

FIG. 2.—Composition of deer kill, Colorado, 1941, as determined from checking station data.

Aging and Weight

The best method so far worked out for aging and determining weight of deer in Colorado is based on certain measurements made on animals killed during the regular hunting season. These measurements are diameter of beam one inch above the burr, length of beam to first fork, and girth before splitting the brisket. The latter measurement is for weight and is taken with a "Game Weight Tape," calibrated in pounds and in diameters expressed in inches. Age is not determined on the basis of weight, but, when correlated with weight, supplies an excellent indication of range condition. These aging and weight techniques were found to be 97 per cent accurate, as determined from careful dentition studies. Complete description of both processes is

given by Hunter (1947).

This method of determining age on the basis of external physical measurements was developed primarily as an aid to Department game technicians. The simple procedure involved permits the taking of a large sample by semi-skilled assistants, and the information obtained serves to indicate the number of each age class to be harvested in order to balance the herd for maximum production or, in other cases, to limit production.

The utility of this system is illustrated in Figure 2 which is indicative of the kill from a normally balanced Colorado mule deer herd.

As long as the youngest age classes provide the principal kill, breeding stock for maximum production is not jeopardized. Assuming that a deviation shows excessive kill of the older age classes—the main breeding stock—protective restrictions must be devised. Armed with this information, and with knowledge pertaining to range conditions and probable hunting pressures, the administrator is in position to develop sounder programs of mule-deer management.

Range Surveys

The constant objective of big-game management in Colorado, and throughout the West, is to maintain balance between herd numbers and the range. Department biologists are charged with this responsibility, and all of them are experienced in range appraisal. Since range condition is weighed more heavily than any other factor in setting big game seasons, Department biologists work closely with Forest Service and Bureau of Land Management experts in determining forage conditions on each of the 59 big game districts. They are also acquainted with stockmen, and are conversant with their needs and interests. Prior to the setting of seasons, information from all sources is evaluated at meetings attended by representatives of the several agencies responsible for public land administration. In this manner, the opinion of all is determined, and unanimous decisions usually achieved. Seasons formulated partly on this basis, and partly on other management factors, such as trend in herd numbers, herd condition, and hunting pressure—the *herd-range-drain* concept—are meeting progressively wider approval in Colorado.

Since range management is regarded as the key to big game management, special attention is being given by the Department to range research, for which purpose the Little Hills Range Experiment Station is being developed. On this 15,000-acre range, various grazing problems are under study, emphasis being given to the forage requirements of mule deer, and to competition between these species and domestic stock. Later, elk, antelope, and mountain sheep are to be studied similarly. Comparable research will be conducted on the Zimmerman Range northwest of Fort Collins, and on the Tarryall Sheep Range southwest of Denver. The techniques used in making the big game range appraisals were described by Deming (1939) and Hunter (1944, 1945).

Refuges

Colorado has relatively few big game refuges, now that the need for this phase of management in the state is not great. During a decade or two prior to 1935, refuges were established by legislative action and played an important

role in the comeback made by both deer and elk in the state. By policy, closed areas are now created only where a game species is in need of protection, or where human use is so heavy as to require this measure of safety. Seven of the 15 closed areas in the state are city parks or other outlying metropolitan areas subject to heavy recreational use. An example of closure in the interest of game is the Tarryall Bighorn Sheep Area, southwest of Denver, where protection is given to a herd estimated at 900 individuals. Since this region involves only about 150 square miles, and since it is the home of the mother herd from which replanting stock is taken, this closed status is justified. A total of 8 similarly closed areas are now set up in Colorado, of which 2 are for the protection of sheep, 1 for turkeys, 4 for antelope, and 1, Little Hills, where grazing experiments are in progress. Deer and elk no longer require this degree of protection in the state. In the event of antelope seasons, however, any or all of the normally closed areas may be thrown open.

Refuges, as such, may be established in Colorado only by legislative action. The Game and Fish Commission is free, however, to establish closed areas where they appear necessary for the protection of people or an especially important game herd. Recommendations of the technical staff are followed in all cases where such action is taken in the interest of game.

Damage Problems

In Colorado, payment for damage caused by big game or other wildlife is governed by statute. Complaints must be appraised and settled by an arbitration board of 3 members, 1 chosen by the Department, 1 by the claimant, and the third by these 2 members. This board is required to make an unbiased investigation and report its recommendations to the Department. If a claim for damage is allowed, reimbursement is made by check drawn on Game and Fish Department funds. To assist in handling claims, the Department carries on its staff two full-time employees who are thoroughly experienced in damage appraisal and whose integrity is unquestioned. The individuals holding these positions at present (1949) are a retired Forest Supervisor, who served more than 20 years on Colorado national forests; the other is an experienced technician who has been with the Department a number of years. It may be said that current high prices for agricultural products have resulted in an increase in the number of claims during the last year or two, and that settlement has proved relatively difficult. It is apparent that claims will increase during the years immediately ahead.

Damage control is effected in one of several ways, as conditioned by its nature and the species responsible. The most desirable control is herd reduction by hunting during the regular season. Where losses are acute, the Department has the authority to kill animals in season or out, in which case the carcasses must be sold at public auction or given to charitable institutions. Sportsmen formerly protested this method of control vigorously, but the policy of killing only when imperative, and strict adherence to regulations governing carcass disposal, has resulted in a steady decline in both number and vigor of such protests.

The most common form of damage is probably to haystacks and fruit trees.

In such cases, stacks and trees are fenced at Department expense, authorized usually by the Department's representative in charge of damage problems. In regions where elk and deer loss is expected, protective fences are commonly erected during the fall before these animals migrate to their winter range. The season of greatest damage is late winter and early spring. One effective means of controlling elk particularly is by plane, wherein the animals are hazed and often driven many miles from the scene of damage. It has been found that severe frightening by this means may sometimes serve to keep big game animals out of orchards and away from haystacks for several days at a time. One necessity for this method of control is, of course, the availability of a plane and a pilot with some experience in the type of flying required. Attempts by ground crews to frighten deer and elk have proved ineffective as well as costly.

As stated previously, feeding by plane at some distance from ranch property promises to be effective.

Checking Stations

Extensive use of big game checking stations has been made by the Department. These road blocks, placed at the same strategic locations each year and, when necessary, operated 24 hours per day, serve at least 5 purposes:

1. To determine kill trend. Experience has shown that at the end of the *fifth* day of the season it is possible to estimate, within 10 per cent error, the kill of either mule deer or elk on any major game district. This information permits the Department to extend or close the season to insure the proper kill, such action requiring, by statute, but 48 hours' notice. At the end of 10 days, the kill of deer or elk can be estimated within 5 per cent accuracy. The utility of this technique in sound management is too obvious for further comment.

2. To gather scientific data on sex ratio, age classes, and weight in relation to range.

3. To determine crippling loss. One year of experience, when it was determined that 13.8 per cent of the deer and 11.7 per cent of the elk shot at were crippled or lost, indicates the usefulness of this type of information.

4. To determine costs of hunting, non-resident as well as resident.

5. To aid in law enforcement. A warden is ordinarily assigned to each checking station to handle enforcement duties.

The big game kill is determined also through the return of cards by hunters (Figure 3). On this basis, accuracy in calculating the kill for any given season is approximately 96 per cent for deer and 97 per cent for elk, as compared to checking station data. Information supplied on kill return cards affords an additional check on sex and age, and kill by locality. The ratio of return in kill cards is indicated in Table 4.

TABLE 4.—PERCENTAGE OF BIG GAME LICENSE BUYERS RETURNING KILL CARDS, 1945–47

Species	1945	1946	1947	1948
Deer	56	66.4	61.6	55.13
Elk	66	59.6	62.9	57.91
Weighted Average	57	64.6	61.8	56.76

Such information is strongly supplemented at checking stations where number killed by species, sex and age is determined. Other information obtained

in this manner includes the period of kill; kill by species for each game management unit and each county; hunting locality preference for both resident and non-resident hunters; kill by land ownership (National Forest, Bureau of Land Management, private, etc); and the number of points, guns used, and, when desired, cost to hunters (Hunter, 1947; 1949).

SEASON AND LIMITS

In all forms of game management, seasons provide the opportunity for harvesting surpluses of the crops produced. Limits, as regards time and take, offer the mechanism for regulating the harvest equitably between sportsmen and resource. It follows, therefore, that seasons and limits represent 2 of the most important tools of management.

All big game hunters are required by Commission Regulation to send this card to the Game and Fish Commission not later than 15 days after the close of the season. Report must be made whether or not you were successful in killing an animal. Failure to send this report is a violation of Commission Regulations. (Sec. 2, Chap. 103, S. L. 1943.)

Please Check (x) Proper Bracket ( )

I DID KILL AN ELK — Yes ( ) / No ( ) — Left ..... Right ..... Number of Points — Bull ( ) Cow ( ) Calf ( )

AND A BEAR — Yes ( ) / No ( ) — DATE OF KILL.....

(Report Bear on one card only)

Location of Kill — Drainage (Stream) — Upper — Middle — Lower

Nearest Town (To Location of Kill) — County (Where Killed)

Name — Address — Colorado

This Report MUST Be Returned Whether Successful or Not. Postage is paid.

FIG. 3.—Big-game hunting report card, Colorado, back view. Frontside of card contains Game Dept. address, serial number of license, "postage supplied by Dept." and the directions: "Important: This card must be filled out on the reverse side and mailed not later than fifteen days after close of season."

Analysis of the information supplied by kill cards on the Department's International Business Machines permits very rapid evaluation of the data. For example, on 4 hours' notice, the season's kill by species and sex, including fawns and calves, can be determined for any game management unit in the state, including the White River district where 7,161 deer and 3,321 elk were taken in 1948.

It is on the basis of *district*, or *herd*, management that the Department achieves its highest degree of effectiveness. Obviously, the various herds are affected variably by such factors as the amount of summer and winter range, livestock competition, accessibility, and others. Obviously, too, each herd is circumscribed to area limitations by natural barriers, such as mountain ranges, large areas of agricultural land, or

desert. The 59 management units are based on these natural land divisions, which are often watersheds. This principle permits specific management of each herd, for which seasons and limits can be adjusted on the basis of more or less uniform ecological conditions, as well as herd numbers and condition.

Big game regulations in Colorado are made by the Commission, on the basis of recommendations submitted by the Game and Fish Department. Preparatory to submitting its recommendations, the Department holds game management meetings in 25 or 30 key districts for the purpose of correlating its census and range-condition findings with those of the Forest Service, Bureau of Land Management, National Park Service, and other agencies. These district meetings take the form of technical discussions wherein all state and federal organizations having responsibility for land use have full voice. In these conferences, the Department is represented by both its technical and enforcement staffs, and both contribute to the discussion pertaining to each game district.

Following this series of district meetings, a state-wide, 2-day game-management meeting is held in Denver for the purpose of effecting general uniformity in agreement between all land-use agencies. The Forest Service is represented by the Supervisors of the National Forests in Colorado; the Bureau of Land Management by its District Graziers; and National Park Service by its Superintendents or their representatives, usually the Chief Rangers; and the Department by its complete technical game staff and all District Chief Wardens. Recommendations to the Commission are based on agreements reached at this 2-day meeting. Voting on the various questions and proposals is by districts on the basis of facts, not hearsay, wherein the Forest Service, the Bureau of Land Management, the District Technician, and the District Chief Warden each have one vote.

Several variations of the basic big game hunting season are permitted in Colorado. For years the traditional buck or bull season was followed in the state, but since 1940 the trend has been toward a hunters' choice season.

Hunters' choice, as the name implies, permits the hunter to bag either an antlered or antlerless deer or elk, and is restricted to areas having insufficient forage for the number of animals present. Since hunters' choice seasons offer more than double the opportunity of bagging game, hunters tend to crowd into hunters' choice districts. This is particularly true of elk, the female of which is the more highly regarded as food. As an example of this trend, only 88 elk (2.6 per cent) were taken in 1945 in the 7 counties open to antlered elk only, while 3,267 (97.4 per cent) were killed in the remainder of the state, which was open to hunters' choice. The reverse is generally true of deer, as shown in Table 5, adapted from Hunter's (1948) report on the Colorado kill in 1946–1947.

The differential in the deer and elk anterless kill, as reflected in Table 5, suggests different approaches in management. Where the take does not exceed, or only slightly exceeds, one-third, as indicated for deer, there seems little danger of an excessive kill of females. On the other hand, where the female kill in elk exceeds one-half, hunters' choice seasons for this species must be given less frequently and on the basis

of considered judgment. Under the management-unit system, such adjustment can be applied to specific areas, and to the degree necessary, in rectification of any adverse sex ratio that might result from an improper season. This is an excellent example of the effectiveness of flexible seasons and limits in big game management.

In addition to hunters' choice seasons, other parts of the state may have a regular buck or bull season, of which the 1948 dates of October 15–31 for deer and October 15–24 for elk are typical. Other variations include special seasons for such species as antelope or turkey, extension of season, restriction of season, post-seasons and pre-seasons.

Experience has shown that most seasons other than the regular one are not effective. This is particularly true of post-seasons, the main reason for ineffectiveness being (1) decline in interest on part of hunters; (2) bad weather; and (3) deer in rut. The pre-season granted on 2 overpopulated areas in 1948 was effective in reducing the deer herds in question.

The 1949 big game season permits one deer of either sex over the entire range, and two deer, one of which must be antlerless, or two antlerless animals, on about one-third of the range. Naturally the more liberal season applies to problem areas, where reduction in numbers is imperative. In addition, hunters' choice will apply to all elk range except one small area. Here, bulls only will be legal. In 1948, 3,321 elk were killed on this area and the herd reduced to numbers now in balance with the available winter range.

Notwithstanding the advantages presently enjoyed by the Department in the way of big game season flexibility, the following changes are recommended in order to attain still further effectiveness.

1. Permit damagee to kill on own or leased property, under permit, big game animals destructive to crops or property, but require him to deliver dressed carcass to Department or designated institution within a time limit.

2. Give Department right to designate prior to season, the number of deer, elk, and other big game of both sexes to be killed by specific areas, such number to be based on findings of Department biologists. This change will permit a greater degree of herd control, by sexes, than the present regulation.

3. Amend statutes to permit commissioners to succeed themselves. The present single term of 6 years results in the training of good Commissioners, but does not permit utilization of their experience and knowledge for long periods subsequently. Reappointment should not, of course, be obligatory on the part of the Governor.

TABLE 5.—ANTLERED AND ANTERLESS RATIO IN DEER AND ELK KILL, COLORADO, 1948, ON HUNTERS' CHOICE AREAS

Species	Number			Per Cent		
	Antlered	Antlerless	Total	Antlered	Antlerless	Total
Deer	32,441	26,348	58,789	55.2	44.8	100.0
Elk	3,831	6,797	10,628	36.1	63.9	100.0

SUMMARY

1. Big game license sales in Colorado amounted to $1,292,987.25 in 1948.

2. Game administration in Colorado, except for seasons and limits on migratory birds, is achieved through its 6-member, governor-appointed Game and Fish Commission. The progressive attitude of the Commission is of inestimable value to the Game and Fish Department in building a program based on factual information, obtained by trained personnel. Various non-wildlife specialists, good equipment, and experimental areas, add to the efficiency of the technical staff.

3. Big game management is centered in a land-unit organization of 59 districts, each subject to seasons and limits based on range condition, population trend, and hunting pressure.

4. Land area, elevation, use, and ownership profoundly affect big game management in Colorado.

5. Conflicts of varying intensity exist between big game and livestock interests. Mutual understanding of problems by both groups, particularly the necessity of maintaining the range in productive condition, is resulting in improved relationships between the Department and range users.

6. Education is considered of paramount importance by the Department. Sportsmen are kept accurately informed, regardless of whether news is good or bad. Department personnel, particularly biologists, attend and participate in sportsmen's meetings. This policy has won the confidence of the public, with the result that sportsmen's groups, in the main, have become an asset to the Department. The same policy, with fair to good response, is followed with Chambers of Commerce, dude ranchers, and other groups whose interests lead them to capitalize on fish and game.

7. The most serious big game problem in Colorado is the severe lack of winter range, and maintenance of winter range is the constant and paramount problem of management. The chief mechanism for attaining balance is seasons that permit females to be hunted.

8. Big game seasons and limits are based primarily on population numbers and trends. Numbers are determined largely by airplane census, and by estimates based on special indices, such as meadow and roadside counts during migration. All elk counts, all counts of deer on inaccessible areas, and nearly all counts of antelope and bighorn sheep, are by plane. Other population estimates are derived from sample strips or plots. Drives were early proved expensive and inaccurate, and are no longer used.

9. Practically all big game sex and age counts are made by plane, which permits increased accuracy and great saving in time and manpower. The relative cost per head is $0.071 for counts from planes, $0.208 if afoot.

10. Restocking of suitable bighorn sheep, antelope, mountain goat, and wild turkey range is attained through trapping and planting of native wild stock. The liberation of goats was equivalent to an introduction in Colorado. Availability of winter range determines stocking sites in all cases. Deer and elk no longer require this degree of management in the state. The proposed stocking of moose is contingent on the outcome of careful evaluation of conflicts in the event of multiplication of this species.

11. Winter feeding of deer and elk is

now practiced in Colorado only as a means of controlling damage. The feeding problem is being met by adjustment of herds to available winter range. Feeding en masse tended to concentrate deer and elk on range already overcrowded with big game and livestock, and aggravated nutritional and parasitological difficulties and, in some cases increased damage problems.

12. Age determination in deer, in addition to the dentition method, is based on beam diameter and length of beam to the first fork; weight, on girth before splitting the brisket. The latter is determined with the "Game Weight Tape," calibrated in pounds and diameters expressed in inches.

13. Each of the 59 big game districts is subject to an annual survey by Department technicians in determination of range trend and condition. Emphasis is given to surveys on winter range. The information so gathered, when correlated with population data and hunting pressure, supplies the basis for setting annual seasons and limits.

14. Colorado has relatively little need for big game refuges, which may be established in this state only by legislative action. The commission, however, has the authority to open and close specific areas in the interest of human safety or a specific herd or species.

15. Payment for damage caused by big game in Colorado is governed by statute. Complaints are appraised by an arbitration board of 3 members, the Department being represented by a specialist in this field. Control, where needed, is accomplished at Department expense by fencing trees and haystacks, by hazing with plane, and feeding by plane. Ground crews have proved ineffective in frightening deer and elk from damage areas.

16. Checking stations, located at strategic points, are extensively used, and enable the Department to determine kill, to gather scientific data on sex, age, etc., and to determine crippling loss. A warden is usually assigned to each station to handle enforcement duties.

17. Kill cards, returned by 60 per cent of Colorado big game hunters, supply the basis for calculating the annual take of deer and elk, giving 96 per cent or greater accuracy.

18. Big game seasons in Colorado are made by the Commission, on the basis of recommendations submitted by the Game and Fish Department. Such recommendations are supported by factual information gathered at district meetings from state and federal land-use agencies, where the opinions of all representations are received and evaluated. The recommendations of livestock interests, sportsmen, and dude ranchers, are also obtained in public hearings. The unified, statewide, recommendations of the Department, based on populations, range condition, hunting pressure, and other pertinent factors, are reached at a 2-day meeting attended by the ranking representatives of all agencies and interested groups.

19. Big game seasons are flexible in accordance with needs. The trend has been toward hunters' choice on both deer and elk, wherein all animals are legal. Other variations include pre- and post-seasons, extension of seasons and bag limits, and special seasons on antelope and wild turkey. Post-seasons have been of little value in achieving a desirable kill.

20. Hunters have shown a distinct preference for buck deer and cow elk, the latter undoubtedly because of the better quality of the meat.

21. The Department, while grateful for the advantages presently enjoyed as the result of flexibility in seasons, limits, and general operation, favors amendments that would, (1) permit damagee to kill, under permit on own or leased property, big game animals destructive to crops or property; (2) give Department authority to designate number and sex of big game to be killed by districts, with right to close season when this kill is attained; and (3) to permit Commissioners to succeed themselves.

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PRODUCTIVITY DATA FROM PLACENTAL SCARS IN BEAVERS[1]

Kenneth W. Hodgdon

It has long been established that a knowledge of the productivity of a species is essential to proper management. The scarcity of published data on the productivity of the beaver (*Castor canadensis canadensis* Kuhl) prompted the inauguration of a study to gather this information.

Some work has been done on beaver reproduction in other states. Bradt (1947) counted embryos from animals taken in Michigan during the spring trapping season of 1935. In Maine, however, the trapping season was during December and January in 1946–47, and from January 1 to February 7 in 1948. No embryos were present during these periods. Permission was granted by the Commissioner of Inland Fisheries and Game to trap a few beavers in the spring for the purpose of obtaining embryo counts. This provided only four pregnant females the first season and proved helpful but inadequate. In 1948 a study of placental scars in beaver uteri collected during the trapping season was conducted in conjunction with gathering other data. The results of this study follow.

Methods

To determine the number and locations of placental scars the uterus, adjoining mesenteries, ovaries and bladder were removed from the carcass in one piece. With the ventrally attached bladder it was easy to distinguish the right from the left horn of the uterus. The mesenteries adjoining the horns of the uterus usually contained small areas of congested, minute blood vessels radiating from the placental scars thereby leading the observer to inspect that part of the uterine horn. By taking one horn at a time and holding the mesentery and horn flat between the fingers in front of a strong light one could observe the placental scars which appear as dark spots of varying size, in contrast to the pink appearance of the uterus. The older animals had thicker and less translucent uteri thus requiring stronger light. Occasionally sunlight was used to good advantage as a source of illumination both for examining the uteri and for photographing with daylight type color film.

A modification of the above method of locating and counting the scars was to stretch the uterus out in a U-shape on a pane of glass and direct a strong light toward it from the back side. By this method any doubt as to whether the dark spots were placental scars or small folds in the uterine horn was dispelled by pressing the horn flat against the glass with the fingers, thus "ironing out" any extra folds. The uteri were so prepared for photographing as well as for examination.

In addition, a supplementary means of locating and counting the placental scars was to run the fingers along the

[1] Contribution from Pittman-Robertson Project 9-R. The writer wishes to acknowledge the kind and helpful advice and assistance given by Dr. Carl M. Flynn, Zoology Dept., University of Maine, and Jay S. Gashwiler, Ass't. Leader, Maine Cooperative Wildlife Research Unit, University of Maine.

uterine horns to feel the thickness. Where placental scars occurred a noticeable thickening could be felt in nearly all instances.

RESULTS AND DISCUSSION

During the study 155 specimens were examined, of which 39 were adult females. Of these females 20 possessed uteri with placental scars. Table 1 presents the data regarding the productivity of these 20 females. The smallest weighed 30 lbs. entire and 24 lbs. "rough-skinned" and had two placental scars. Since all other specimens were larger it was assumed that they were at least as old and therefore capable of having placental scars. "Rough-skinned" is the term used to describe the usual method trappers employ in skinning beavers; i.e., cutting off all feet and taking part of the flesh with the skin. There are some variations in "rough-skinned" weights.

Because the project personnel collected the larger carcasses primarily, the group studied could not be considered a random sample. However, the fact that nearly one-half of the adult females lacked placental scars may not be too high in view of the fact that these scars were the result of pregnancies in 1947 and the trapping season that year (December, 1946 and January, 1947) was prior to the breeding season according to studies by this project. Beavers are generally considered to have only one mate and there is usually only one family in a pond, the exceptions to the latter being mainly the larger ponds, lakes, and bog deadwaters. During the breeding season they are locked in by ice, therefore if only the adult male had been caught during the 1946–47 trapping season there would have been no young born that spring.

The average of 3.95 placental scars per female, the result of pregnancy in 1947, indicates a close correspondence with the findings of Bradt (1947) who states that of 65 litters studied in 1935, the average number of embryos or kits was 3.72, with individual variations ranging from one to eight. Eight embryo and three litter counts made by this project averaged 3.55. Table 2 compares these results.

TABLE 1.—NUMBER OF OCCURRENCES AND DISTRIBUTION OF PLACENTAL SCARS

No. of Occurrences	No. of Placental Scars		
	Right Horn	Left Horn	Total
1	1	1	2
1	2	0	2
2	2	1	6
2	1	2	6
1	3	0	3
3	1	3	12
2	3	1	8
1	0	4	4
3	2	2	12
1	3	2	5
2	3	3	12
1	3	4	7
20			79

Average number of placental scars, 3.95.

In appearance, the uterus of a yearling female is small, relatively straight, and of course, without placental scars. However, in the uterine horns of the larger females "loops" of various sizes often were observed and it is thought that placentation had occurred there in some previous year and the horn had not returned to its original shape. Some "loops" were very pronounced, and these seemed to be in the largest specimens. In others, usually the smaller specimens, the "loops" were less definite

and commonly contained placental scars. This difference in "loop" size is possibly the result of repeated placentation occurring in the vicinity of the "loop," over a period of years, in the case of the large specimens. The smaller females apparently were too young to have become pregnant enough times to form large "loops." Often these "loops" contained placental scars, indicating that the female had young the previous year, but four were found to have "loops" and no placental scars whatever.

TABLE 2.—COMPARISON OF LITTER AND EMBRYO, AND PLACENTAL SCAR COUNTS

No. in Litter	Number of Occurrences		
	Maine Litter & Embryo Counts	Michigan Litter & Embryo Counts	Maine Placental Scar Counts
1	1	5	0
2	5*	11	2
3	0	11	5
4	0	20	9
5	3	9	1
6	1**	7	2
7	1	1	1
8	0	1	0
Averages	3.55	3.72	3.95

* Two are litter counts.
** Litter count.

This would indicate that the scars may disappear, and the similarity in the results of this study and Michigan's litter and embryo counts suggests that they are evident only in the year following pregnancy.

Dozier (1947) relates one instance of resorption of embryos in muskrats out of over 15,000 females examined. Because of the similarity between beavers and muskrats it is possible that this occurs in the former but none has been recorded.

Shadle (1930) gives data on the birth of a litter of six kits of which three died (two accidentally) shortly afterwards. Bradt (1947) found that the number of embryos per female and the number of kits per colony gave practically the same figure for the average number of young per litter. Since Bradt studied 65 litters and Shadle reported on one, Bradt's results would be more representative. This, together with the Maine data based on 11 litters, indicates that infant mortality may be low among beavers in Maine and if so, the placental scars should be a relatively accurate index of productivity when obtained in sufficient quantity.

SUMMARY

Methods of locating and counting placental scars are discussed.

A study of 155 beaver carcasses showed 39 as adult females, 20 of which had placental scars.

An average of 3.95 placental scars was found for the females pregnant in 1947.

In three litter and eight embryo counts, the average number of young was 3.55.

The data presented suggest that placental scars persist for only one year.

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BRIEFER ARTICLES

EFFECT OF DDT ON BIRDS IN GEORGIA PECAN ORCHARDS WITH A NOTE ON LATE SUMMER CENSUS METHODS

The use of DDT in experimental orchards at Albany, Georgia and elsewhere indicated that this insecticide can effectively control the pecan weevil, *Curculio caryae* (See Moznette, G. F. DDT for pecan weevil control in the southeastern states. Bull. E-723, U.S.D.A. Bureau of Entomology and Plant Quarantine.). Accordingly, DDT was recommended for general use in controlling this pest, and was first used by private orchard owners during the summer of 1947. Since the amounts of DDT required for control of the pecan weevil are high, it seemed worthwhile to evaluate the program from the standpoint of its effect on birds. The present study was a part of an extensive program of the Fish and Wildlife Service which deals with wildlife in relation to insecticidal control. We were also interested in obtaining information on orchard populations for comparison with populations of natural communities of the southeast currently being studied. We are indebted to Joseph P. Linduska for suggesting the problem and reading the manuscripts, to G. F. Moznette of the Bureau of Entomology and Plant Quarantine, Albany, Georgia, who supplied us with names of orchard owners who planned to try DDT, and to the orchard owners themselves who were, without exception, extremely cordial in allowing us free access to their orchards.

Between July 30 and August 28, 1947, ten pecan groves were under observation. Five of these were located in the coastal plain and five in the piedmont region of Georgia. Four of the groves received one application of DDT, three received two applications,—the second about two weeks after the first,—and three groves not sprayed served as controls. Orchard owners used 6 pounds of a 50 per cent wettable DDT powder (equivalent to 3 pounds of DDT) to each 100 gallons of spray which was applied to individual trees by small power sprayers operated from the ground (little or no spray reached the ground or fell on areas between trees). The amount of solution applied by individual owners varied rather widely so that the quantity of DDT actually deposited ranged from 2.0 lbs. to 6.5 lbs. per acre (average 4.3) or 0.18 to 0.43 lbs. per pecan tree. Although this represented a rather heavy concentration on individual trees the total amount of DDT used in the orchards studied in 1947 was in some cases not as great as had been recommended by Moznette. The high cost of the wettable powder, a light weevil infestation and heavy rains were factors which caused several owners to restrict applications.

METHODS.—A well-tended pecan orchard is a uniform and specialized habitat for birds. It is, in fact, an even-aged forest community with one exclusive dominant, without a shrub layer and usually without an herb layer. While a fairly large number of species frequent the orchards, only a few species find all of their requirements within the orchards, most species depending on adjacent hedgerows, fields or farm building environments for part of their food and nesting requirements. Thus, the nature of the habitat made it easy to count and map birds observed, but the instability of population, especially in late summer, made it difficult to determine a reliable population index that could be used for comparative purposes. We found that late summer bird populations in Georgia pecan orchards comprised three components: (1) birds still holding territory, singing, or nesting in or partly within the orchard (individuals of about 5 species); (2) birds which include all or part of the orchard within their regular feeding ranges but which do not remain in the orchard continually (the bulk of the population); (3) birds, largely flocks of roving juveniles and transient warblers and vireos, which merely pass through the orchards or remain in it only a short time. Since the total population is largely fluid we feel that the only meaningful estimate that can be given is the average number of birds observed per acre (or per 100 acres), using a relatively uniform time limit,—approximately one hour during the forenoon for each ten acres in the case of our study. We have

designated this as the "time-area" method to distinguish it from the "territory-mapping" method commonly used in censusing more stable breeding populations. This population index was determined before and after spraying operations by slowly cruising each orchard and plotting the location and activities of all birds on outline maps. From these maps the total number of birds carrying on definite feeding or nesting activities in the orchard was determined, birds in the third category listed above (i.e., transients, roving juveniles, and chance visitors) being eliminated since it is neither possible nor desirable to include this highly variable element on a comparative basis with the regular orchard inhabitants. Although more study is needed we feel that the population, as so delimited, is fairly constant even though individuals of the population are continually entering and leaving the orchard. Thus, figures in table 1 indicate the average number of birds present in the orchards at a given time.

TABLE 1.—AVERAGE LATE SUMMER BIRD POPULATIONS IN DDT-SPRAYED AND UNSPRAYED GEORGIA PECAN ORCHARDS

Orchards Sprayed with DDT	Locality	Area in Acres	Number of Times Sprayed	Concentration of DDT in Pounds		Average Population Birds per 100 Acres		
				per Acre	per Tree	Before Spraying, Late July	After 1st Spraying, Mid-Aug.	After 2nd Spraying, Late Aug.
	Marshallville	25	2	4.5	0.30	80	72	42
	Richland	32	2	6.5	0.43	76	106	88
	Social Circle	43	2	2.5	0.18	50	45	30
	do.	40	1	2.0	0.27*	80	63	—
	Averages			4.0	0.30	72	72	53
Control Orchard	Social Circle	20	0	—	—	67	60	40

* Only two-thirds of trees were sprayed (resistant varieties not sprayed); hence the higher concentration per tree.

RESULTS.—Despite the variation in surrounding habitat, the average number of birds observed (eliminating transients and juveniles) was reasonably uniform for various orchards, and ranged from 0.5 to 1.04 birds per acre, or 50 to 104 per 100 acres in unsprayed orchards in late July and early August. There was no appreciable difference in either total abundance or species composition in orchards in the piedmont region as compared with those on the coastal plain. The commonest of the regular inhabitants (listed in the order of total abundance in all ten orchards) were as follows: blue jay, chipping sparrow, field sparrow, bluebird, mourning dove, cardinal, English sparrow, wood pewee. Some individuals, at least, of the following species were still nesting, holding territory, or singing regularly: field sparrow, bluebird, mourning dove, blue grosbeak, and indigo bunting. Additional species present in two or more orchards were: kingbird, mockingbird, bob-white, yellow-billed cuckoo, and hummingbird. Pecan orchards may supply fairly important nesting and feeding cover for the mourning dove, an important game bird of this region, especially if cover crops are planted under the trees.

The average populations in the five orchards observed most closely are given in table 1. Inclusion of less complete observations on the other five orchards would not materially affect these figures. Although populations decreased after the second spraying in late August this was paralleled by a similar decrease in control orchards. General observation indicated that, while large roving flocks may temporarily raise populations, a late August decrease in number of regular

adult inhabitants is normal, since breeding birds begin to leave and birds in general range more widely at that time, tending to spend less time in the orchard. No dead birds or birds showing symptoms of DDT poisoning were found. Of four nests observed before and after spraying (field sparrow, mourning dove, two bluebirds), three progressed normally, neither eggs nor young being affected by DDT. One bluebird nest with eggs in a fence post bordering an orchard was deserted after the second spraying, but no clue as to the cause could be found.

For 24 or more hours following spraying operations dead and dying insects (representing 11 orders and 32 families, as determined by random collections in 4 orchards) were very conspicuous on the sparsely covered or bare ground under the trees. An unusual opportunity was thus provided to observe the extent to which birds feed on poisoned insects. Except for one blue jay, a pair of bob-whites, two brown thrashers, and a flock of English sparrows actually observed feeding on DDT-killed insects, birds in general did not seem to be attracted to the conspicuous piles of fallen insects but continued to remain in their normal niches and hunt for live prey. The DDT-killed insects largely remained untouched until decayed or carried off by ants. This may be an important factor in reducing the hazard to birds.

SUMMARY.—July and August observations on 10 pecan orchards in Georgia, seven of them sprayed once or twice with DDT, failed to yield any evidence of bird mortality. The spray schedule in these orchards involved DDT in amounts of 2 to 6.5 lbs. per acre. In connection with other types of insect control, DDT in these amounts has been observed to cause considerable mortality among birds (Linduska, personal communication). The fact that high dosages used for control of pecan weevils had no apparent effect on bird populations is probably due in large part to the following factors: (1) The late summer feeding range of many inhabitants of groves is larger than or extends to points outside the grove, reducing the contact with the insecticide; (2) in late summer only a few individuals of 4 or 5 species may be expected to be still nesting in the groves; (3) few birds seem to be attracted to or feed upon DDT-killed insects although the latter are often very conspicuous on the bare ground under the trees. It should be cautioned that amounts of DDT greater than 6.5 lbs. per acre have been recommended for weevil control and are likely to be used in the event of heavy weevil infestation. These high concentrations may become critical to birds despite above minimizing factors.

A "time-area" method is described for determining a reliable index to the partly fluid populations of a specialized habitat in late summer. Average total populations varied from 50 to 104 birds per 100 acres in unsprayed orchards in late July and early August with the following species (listed in order of abundance) being the most important of regular orchard inhabitants: blue jay, chipping sparrow, field sparrow, bluebird, mourning dove, cardinal, English sparrow and wood pewee.—EUGENE P. ODUM and ROBERT A. NORRIS, *University of Georgia, Athens.*

BIGHORN—DEER FOOD RELATIONSHIPS IN SOUTHERN NEW MEXICO

The attention of game management agencies, particularly in the southwestern United States has been directed, in several instances, to the restoration of the native sheep. As a paucity of information exists in the literature concerning bighorn–deer food relationships, it appears to be desirable to record the results of a qualitative administrative food study conducted for the past seven years on the San Andres National Wildlife Refuge under the administration of the Fish and Wildlife Service, U. S. Department of the Interior. This study admittedly is incomplete when compared to exhaustive research projects. However, the area involved is an example of the successful restoration of bighorns in New Mexico and so it would seem of value to place on record our findings, with the thought that others working with native sheep may be benefited and stimulated to carry the work further.

The San Andres Refuge is located in

south-central New Mexico, in Dona Ana County. In 1938, J. Stokely Ligon prepared a special report on this area stating in part that bighorn restoration is dependent primarily on control of natural enemies. This management plan was put into effect by the Fish and Wildlife Service with the result that this herd of Mexican bighorn (*Ovis canadensis mexicana*) was brought from the background, we present the food data in some detail.

Deer and bighorn were found to be using the same range. The bighorns were found in limited numbers along the crest of the San Andres Mountains when the refuge was created in 1941, and the deer were found from the crests to the edges of the nearby plains that flank this narrow north and south

TABLE 1.—ANNOTATED LIST OF PLANTS USED BY BIGHORN AND DEER: SAN ANDRES NATIONAL WILDLIFE REFUGE, NEW MEXICO

Plant	Month of Use																								Notes
	Bighorn												Deer												
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
Silktassel (*Garrya wrightii*)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		Winter use for both species heaviest.
Mt. Mahogany (*Cercocarpus breviflorus*)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Winter use for both species harvest.
Sotol (*Dasylirion wheeleri*)			x	x	x	x	x	x				x			x	x	x	x	x					
Fendlerbush (*Fendlera rupicola*)		x	x					x						x	x										Heaviest use for bighorn and deer in Feb. and March.
Big Mallow (*Sphaeralcea incana*)					x	x	x	x	x			x				x	x	x	x	x					
Prickly Pear (*Opuntia sp.*)							x	x	x	x	x	x						x	x	x	x	x	x	x	
Yucca (*Yucca baccata*)			x	x	x	x										x	x	x	x						
Agave (*Agave parryi*)					x	x	x	x	x									x	x	x					
Wild Onion (*Allium sp.*)								x	x									x							
Buttonbush (*Viguiera stenoloba*)								x				x													
Apache Plume (*Fallugia paradoxa*)						x												x						x	Heavily used by cattle.
Apache Plume (*Dalea formosa*)			x	x																					
Apache Plume (*Paronychis jamesii*)			x																						
Eriogonum (*Eriogonum jamesii*)						x	x							x											
Eriogonum (*Fendlerella cymosa*)						x																			
Spiderwort (*Tradescantia wrightii*)								x													x				
Ocotillo (*Fouquieria splendens*)							x		x											x					
Day Flower (*Commelina crispa*)									x																
Star-leaf (*Choisya dumosa*)					x																				
Milkweed (*Asclepias sp.*)					x																				
Snakeweed (*Gutierrezia sp.*)					x																				
Mormon Tea (*Ephedra sp.*)					x			x	x																
Mormon Tea (*Forsellesia spinescens*)					x																				
Horsebrush (*Parthenium incanum*)								x																	
Myrtle Croton (*Bernardia myricaefolia*)									x											x					
Lippia (*Lippia wrightii*)									x																
Rhus (*Rhus choriophylla*)									x																
Virgin Bower (*Clematis drummondii*)								x																	
Stipa (*Stipa neomexicana*)					x																				Utilized when green.
Cottontop (*Trichachne californica*)								x																	
Gramma Grasses (*B. eriopoda*) and (*B. curtipendula*)								x													x				
Green Sprangletop (*Leptochloa dubia*)									x																

brink of oblivion to the reality of a healthy growing band that is now known to contain at least one hundred animals. Briefly, the management policies have included the exclusion of domestic sheep and goats, moderate grazing of cattle, the elimination of feral stock, local public education, the removal of excess deer by legal hunting under Federal-State supervision, intensive patrol, and persistent predator control.

With the foregoing policies in mind as lying semi-desert range. Permission was secured to take a few deer to ascertain the types of food they were eating as determined from stomach analyses. These determinations are found in Table 1 and are represented by an underlined "x." The remainder of the data was secured by direct field observations of sheep and deer. We are indebted to Mr. Ralph Imler of the Denver Laboratory of the Fish and Wildlife Service for the stomach determinations. The plant data were secured

by watching the animals feed on a given plant and then collecting that plant as the animal moved away. Identifications of this material were facilitated by the presence of a complete herbarium maintained by the Forest Service at the headquarters of the Jornada Experimental Range, which location also is the headquarters of the refuge.

Table 1 lists 33 plants fed upon by bighorns. It is known that this list is not complete, and it is believed that if every plant eaten by bighorns were listed it might ultimately include almost every plant on the range. Of the 33 plants listed, 15 are known by us to have been eaten by deer also. Doubtless, some of the remaining 18 plants are consumed by deer, but for the purpose of this paper we are limiting ourselves to local data. Van Dersal (1938) in his comprehensive study of the native woody plants of the United States has well covered the literature in listing the food plants of game birds and animals on a national scale, and the reader is referred to that work for the more general and comprehensive data it contains. The following paragraphs explain in some detail various items recorded in Table 1.

The order of listing of the table has comparatively little significance except that the first eight plants recorded are dominants or co-dominants on the range and are important food plants for both species. Comparatively little data are available on the grasses. When the grasses are green as a result of the summer rains, however, sheep and deer eagerly seek out the green blades when feeding on slopes containing browse, herbs, and grass.

The fendlerbush starts growth in the late winter and the tender twigs of this plant are an important feed at that time. The succulent new growth of yucca and agave are eagerly sought by bighorns, deer, and domestic stock. It is of interest to note here that cattlemen of this area sometimes carry a machete on the saddle to cut down the stalks of agave for their livestock. Cattle raised on a range where this type of management is practiced will follow a rider from plant to plant as the succulent stalks are made available.

Silktassel is a key plant in the management of this range. It is used yearlong by both deer and sheep. In certain local and isolated spots where deer have concentrated, this plant is being eaten faster than it is growing.

In summary we can state at this time that it is known that deer and bighorn compete for food on this range. The percentage of this competition was not determined by this field survey which was carried forward incidental to regular refuge administrative work. Bighorn sheep are increasing on the area as are deer. To date the range has remained in good condition and will remain so as long as buck and doe deer, which now number approximately 1100, continue to be controlled by removal from the range under the supervision of the cooperating Federal and State agencies.—ARTHUR F. HALLORAN, *Fish and Wildlife Service, Yuma, Arizona;* and CECIL A. KENNEDY, *Fish and Wildlife Service, Las Cruces, New Mexico.*

THE FUNGUS (*HAPLOSPORANGIUM PARVUM*) IN THE LUNGS OF THE BEAVER (*CASTOR CANADENSIS*)[1]

The lungs of a beaver trapped in Aitkin County, Minnesota, on March 31, 1941, by F. H. Heuer were found on examination to be spotted with thousands of small white pearl-like nodules (Plate 15, A) which occurred throughout the entire organ. They were readily visible to the naked eye.

At first it was thought that the nodules might be caused by the tubercle bacillus, but acid fast tests were negative. When a single organism was removed from its enveloping nodule or cyst it presented somewhat the appearance of a trematode metacercaria, but

[1] Paper No. 2430 Scientific Journal Series, Minnesota Agricultural Experiment Station St. Paul, Division of Entomology, University of Minnesota and the Minnesota Division of Game and Fish, Pittman-Robertson Project 11-R.

its internal protoplasm was undifferentiated. Various specialists in the Medical School and the Divisions of Entomology and Veterinary Medicine at the University of Minnesota examined the infected tissue and slides of it, but none could name the organism.

There the matter rested until one day in January, 1948, when I chanced to read an article by William L. Jellison, "An undetermined parasite in the lungs of the rock rabbit, *Ochotona princeps* Richardson (Lagomorpha: Ochotonidae)," Proceedings of the Helminthological Society of Washington, 14: 75–77, 1947.

Jellison's description of the organism and the accompanying photographs made me feel sure that he was dealing with the same organism that I had found in the beaver. Specimens of infected beaver lung and photographs of the same sent to him confirmed this suspicion. He suggested that I send material to Dr. E. Silver Dowding, mycologist at the University of Alberta, who had seen his article and suggested that he had found an infection of *Haplosporangium parvum*.

Photographs of the organism from the beaver and specimens of infected lung tissue sent to Dr. Dowding were identified as being similar to, if not identical with, *H. parvum*.

The cyst wall of *H. parvum* from the beaver, Plate 15, B, surrounding the chlamydospore is made up of two layers. The inner, which is about 0.21 mm. thick, consists largely of fibrous connective tissue; the outer, which is about 0.50 mm. thick consists of polymorphonuclear leucocytes and lymphocytes and a small amount of connective tissue. The cyst wall surrounding the invading organism is probably formed wholly of host tissue. The chlamydospore, which can easily be removed from the cyst, is shown on Plate 15, C. It is 209 micra in diameter. The dense outer covering is 22.8 micra thick, and its internal protoplasm is undifferentiated.

H. parvum, according to Dowding, Canadian Journal of Research, E, 25: 195–206, October, 1947, "The pulmonary fungus, *Haplosporangium parvum*, and its relationships with some human pathogens," has occurred in the white-footed mouse (*Peromyscus maniculatus*) and the red squirrel (*Tamiasciurus hudsonicus*) from Alberta, Canada.

Emmon and Ashburn, Public Health Report 57: 1715–1727, 1942, first described *H. parvum* from the lungs of pocket mice (*Perognathus baileyi*) and (*P. penicillatus*), kangaroo rat (*Dipodomys merriami*), ground squirrel (*Citellus harrisii*), grasshopper mouse (*Onychomys torridus*), and deer mouse (*Peromyscus eremicus*).

Experiments conducted by Dr. Dowding indicate that sporangia of *H. parvum*, which develop from the mycelium during the saprophytic phase of the fungus, are not air borne but are adhesive and transferred by contact. *H. parvum* probably maintains itself in the soil where rodents come into contact with the adhesive sporangia. The sporangial walls probably dissolve in the moist environment of the nostrils and the sporangiospores are inhaled. Then they develop in the lungs into the large parasitic chlamydospores that are visible to the unaided eye. After the death of an infected animal the chlamydospores germinate in the soil and the saprophytic phase of the fungus begins.

Lung tissue suspected of being infected by *H. parvum* may be cultured on Sabouraud's agar at *room temperatures*. Dr. Dowding's article contains photographs and descriptions of the cultural characteristics of this fungus on agar. Lung infections of wild rodents of the type described which do not yield acid fast stains should be checked for fungus infections.

Further information on the effects of this fungus on the host would be desirable. Heavy infections must almost certainly be pathogenic. Because of the large size of the organism, rather extensive tissue reaction occurs in the host.—ARNOLD B. ERICKSON, *1005 Commerce Building, St. Paul 1, Minnesota.*

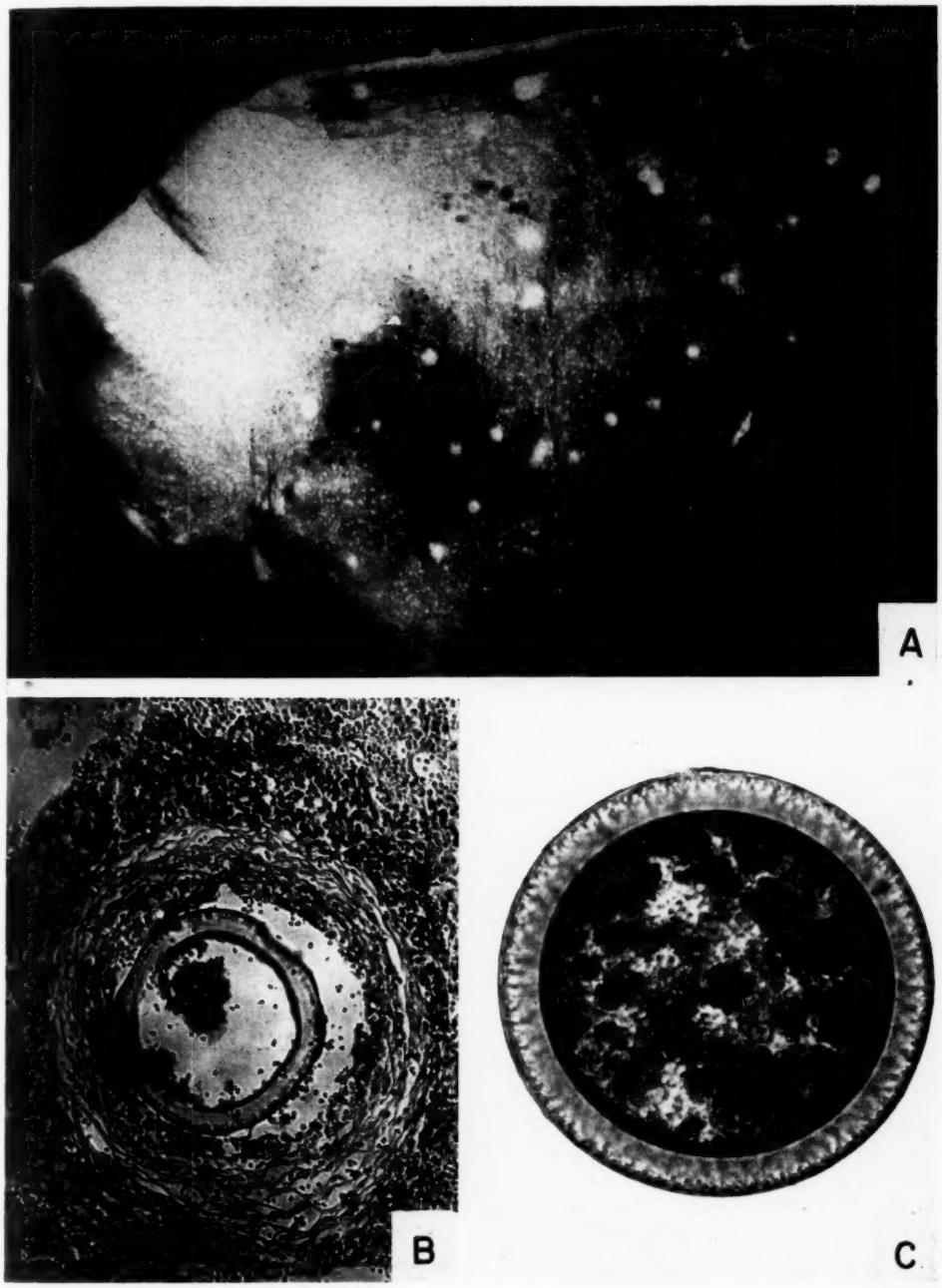

PLATE 15, *A*.—Gross appearance of a piece of beaver lung parasitized by *Haplosporangium parvum*. ×4. *B*.—Section of beaver lung containing a chlamydospore of *Haplosporangium parvum* enclosed within a double cyst wall. ×140. *C*.—Chlamydospore of *H. parvum* removed from the cyst. ×200.

PLATE 16.—Characteristic view of the vegetation on the area described. *A*. Dense stand of balsamroot and grass with occasional dead sagebrush. *B*. Peppergrass in foreground, dense sage in background. Note single small plant of balsamroot.

EFFECTS OF MULE DEER AND LIVESTOCK UPON A FOOTHILL RANGE IN NORTHERN UTAH

Winter deer ranges throughout Utah, and much of the intermountain country, also serve as spring and early summer and fall grazing areas for livestock. Much of this land is privately owned and the owners have resented the presence of deer during the winter and early spring period, before livestock were permitted to graze the area. They believe that much forage is removed before livestock can utilize it. Further, it is commonly felt that damage from trampling results from grazing by game animals in the early spring period after snow has melted.

There is such an area east of the Utah State Agricultural College in Logan, Utah, which has been used by both game and livestock during the past several years. This area seemed to offer promise of revealing the comparative influences of the use by deer and cattle on range vegetation.

DESCRIPTION AND HISTORY OF THE AREA

The area from which the following data were secured lies at an altitude of 5,000 feet and occupies a narrow strip between the national forest boundary above and the cultivated lands below. It extends for a distance of approximately 2 miles between two prominent canyons which have served as travel routes for deer migrating from the summer range and, hence, deer have tended to congregate in the area. Until 1937, the entire area was grazed by cattle and horses during the spring and early summer. In 1937, a portion of the area was purchased by the Utah State and Fish Game Commission, and livestock were thereafter excluded. The remainder of the area has undergone continued heavy use by a herd of milk cows and a team of horses and grazing begins extremely early in the spring. Immediately following the acquisition of the property by the State of Utah, in consequence of the heavy populations of deer and severe winters, feeding of deer was conducted in the state owned property. No feeding operations have been undertaken for the past 5 years, but the natural migration routes of the deer have

TABLE 1.—NUMBER OF PLANTS FOUND IN A SERIES OF PLOTS ON RANGES ONE OF WHICH WAS USED BY DEER EXCLUSIVELY AND ONE BY LIVESTOCK WITH LIGHT DEER USE

	Deer Range		Livestock Range	
	Total Plants	Number of Plots Upon Which Plants Occurred	Total Plants	Number of Plots Upon Which Plants Occurred
Forbs				
Achillea lanulosa	166	15	312	36
Agoseris sp.	88	16	0	0
Balsamorhiza sagittata	676	47	96	17
Helianthella uniflora	243	31	3	3
Helianthus annuus	0	0	69	3
Wyethia amplexicaulis	64	21	8	5
Grasses				
Agropyron inerme	24	14	9	8
Koeleria cristata	8	3	1	1
Poa pratensis	0	3	0	2*
Poa secunda	1,610	68	667	64
Browse				
Artemisia tridentata (dead)	185	64	92	38
Artemisia tridentata (live)	88	38	580	64
Chrysothamnus nauseosus	2	2	23	16
Gutierrezia sarothrae	29	8	185	33

* Occurred as small patches only.

tended to concentrate them in the state property rather than on the area grazed by livestock.

Although deer have during the years utilized both areas, the factors just described have tended to cause greater pressure on the north part of the area. A fence prevents livestock from utilizing any but the south half of the range.

RESULTS

In June, 1948, vegetation data were secured from a series of 100 square foot plots on each side of the fence, which so far as livestock are concerned, separates the area into two zones. One series of plots was distributed along a transect roughly at right angles to the division fence. Another pair of transects was extended parallel to the fence crossing the first transect at right angles. One of these was within the deer range, the other in the cattle range. Seventy plots were delimited in each area. Vegetation data were recorded as number of individuals of each species. Table 1 summarizes the data thus secured.

It is evident from the above table that marked differences exist in the vegetation upon the two areas. Although no past records exist to substantiate the fact, these changes have been observed to have taken place over the past eleven seasons.

On the deer range, balsamroot has increased tremendously. During the season that it is in bloom the area has the appearance of a flower garden. This impression is undoubtedly heightened by the fact that sagebrush is dead throughout much of the area. This contrasts with the appearance of the area grazed by livestock. Only an occasional plant of *Balsamorhiza* is to be found on the higher slopes adjacent to the national forest boundary where grazing pressure from livestock is greatly reduced by topography. Furthermore, the area grazed by livestock has a dense stand of sagebrush. Few dead plants are evident. Plate 16, A, shows the aspect of the two areas as they appeared in 1948.

Wyethia, a very palatable forage for deer hasn't made the increase that balsamroot exhibits. Although it is not yet abundant in the deer range, it appears to be increasing, since seedlings are frequently to be found. Although it is closely cropped early in the spring full growth is attained after deer leave the area. *Wyethia* is not considered to be highly preferred by livestock. Its near absence in the livestock area may be explained by the close utilization of all plants, a result of extremely close cropping.

Helianthella, which is quite prominent, occurring in nearly half the plots on the deer range, was found in only 3 plots in the livestock pasture. By contrast, *Helianthus*, a worthless annual was found only in the cattle grazed area.

Although marked increases have taken place in the abundance of grass on the deer range it is evident from the data presented that the area is not yet recovered from earlier heavy use by livestock. *Poa secunda* is an early growing bunch grass which spreads more rapidly than other species with which it associates. Further, because of its growth form and early maturing habit it is one of the last to succumb to overgrazing. There are now more than two times the number of plants in the state property as compared to the cow pasture.

Agropyron inerme, a more nearly climax species, although more abundant on the deer range has not yet made the recovery exhibited by *Poa*. The plant spreads but slowly in northern Utah. The individual plants were observed to be much larger, however, and more vigorous where they were protected from grazing by livestock.

Neither *Koeleria* nor *Poa pratensis* were prominent in either area. Only two small clumps of the latter species were found in the livestock pasture, whereas, in each plot in which it occurred in the deer range it covered more than half the entire plot.

Chrysothamnus and *Gutierrezia*, both of little or no forage value, were considerably more abundant in the area subject to livestock use.

Sagebrush has been killed out in much of the area used by deer. This phenomenon has been observed frequently under heavy deer use. Dead plants were more than 2 times as abundant as live plants throughout the area. Possibly this figure is low since some plants may so have disintegrated as to leave no trace of their presence. In the livestock

pasture dead plants of sagebrush were less than one sixth as abundant as were live plants.

SUMMARY

Vegetation data were secured from two series of 70 plots, 100 square feet in size. The plots in one series were distributed through an area heavily grazed by a herd of milk cows and horses throughout the spring and early summer. The other adjacent area has been protected from livestock grazing for the past 11 years but has been utilized heavily by mule deer during the winter and early spring.

Perennial forbs were found to be much more prominent in the area from which livestock have been excluded. Balsamroot was six times as abundant, and *Helianthella* almost eighty times as abundant in the deer grazed area as in the area used by livestock.

Perennial grasses, except for *Poa secunda* which responds quickly to release from grazing, showed less pronounced differences than did the forbs. However, all perennial grasses were both more vigorous and more abundant in the area from which livestock are now excluded.

Much of the sagebrush has been killed by deer browsing. Live plants were much more vigorous and abundant in the livestock pasture.—ARTHUR D. SMITH, *Associate Project Leader, Federal Aid, Utah State Fish and Game Commission, and Associate Professor of Range Management, Utah State College, Logan, Utah.*

COMPETITION OF AMERICAN COOTS AND SHOAL-WATER DUCKS FOR FOOD

The possible interference of the American coot, *Fulica americana americana*, with the feeding of waterfowl has been studied by several investigators. Allan Brooks (Field and Stream, October 1941), stated that coots helped carp destroy beds of pondweeds. He also observed that coots destroyed beds of the water-weed, *Elodea Canadensis*, by their wasteful feeding habits. Wisconsin food-habits research has failed to show this plant to be of even minor importance in this region. J. A. Munro (Can. Journ. Research, D, *17*: 178–186) in an analysis of 45 coot and 91 waterfowl stomachs, concluded that "Competition for food between ducks and coots during the autumn months is negligible." John C. Jones (U.S.D.I., Wildl. Res. Bul. 2, 1940) in an analysis of the stomachs of 792 coots collected throughout the U. S., found that the pondweed family, *Najadaceae*, comprised 40.6 per cent of the total food taken; the sedge family, *Cyperaceae*, 13.7 per cent; algae and muskgrasses, *Algae*, 13.7 per cent; grasses, *Gramineae*, 8.2 per cent, etc.

The analysis of a large number of stomachs from scattered areas is necessary when describing the general food habits of a species, but the problems that arise in small localities are seldom solved by this method of research. A study was therefore planned to learn whether this type of competition existed on a typical Wisconsin marsh. The standard volumetric procedure, as prescribed by the Fish and Wildlife Service, was used in making the following analyses.[1] Items that amounted to less than 0.1 cc. were noted as traces, and grit was not measured since an ample amount was present in all stomachs examined. A summary of the analyses of 32 coot stomachs is presented in Table 1.

The stomach contents of 31 shoal-water ducks, collected during the same period and from the same locality, were also examined. Detailed results will be reported elsewhere but a summary of the analyses is given here. Pondweeds, *Potamogeton* spp., were most important, with a rating of 27 per cent of the total volume. Bulrush, *Scirpus* spp., comprised 26 per cent; coontail, *Ceratophyl-*

[1] I am much indebted to Dr. A. C. Martin and other members of the Patuxent Research Refuge for helping me become familiar with this technique.

TABLE 1.—OCTOBER FOOD HABITS OF 32 AMERICAN COOT ON HORICON MARSH (PART TAKEN IS SEED UNLESS OTHERWISE NOTED)

Common Name	Scientific Name	% Volume		% Occurrence	
Duckweeds	*Lemna* spp.		90.		75.
Star Duckweed	*Lemna trisulca*	76.		88.	
Lesser Duckweed	*Lemna minor*	24.		16.	
Bulrushes	*Scirpus* spp.		3.		50.
River Bulrush	*Scirpus fluviatilis*	81.		56.	
Bulrush	*Scirpus* spp.	19.		69.	
Water Milfoil	*Myriophyllum* sp.		2.		13.
Great Bur reed	*Sparganium eurycarpum*		2.		9.
Sedge	*Carex* sp.		1.		47.
Snail	Gastropoda		T		56.
Coontail	*Ceratophyllum demersum*		T		18.
	(leaves)	50.		50.	
	(seeds)	50.		50.	
Smartweed	*Polygonum lapathifolium*		T		16.
Ergot	*Claviceps purpurea* (grains)		T		16.
Sweet Flag	*Acorus calamus*		T		15.
Insect	Insecta		T		9.
Pondweed	*Potamogeton* sp.		T		6.
Green Algae	Chlorophyceae		T		3.
Beggar-ticks	*Bidens cernua*		T		3.
Dodder	*Cuscuta* sp.		T		3.
Bedstraw	*Galium*		T		3.
Vegetable debris			2.		16.

lum demersum, 19 per cent; oats, *Avena sativa*, 3 per cent; and duckweeds, *Lemna* spp., 2 per cent. Other foods found were relatively unimportant. The only items with a rating of higher than trace in both summaries were the bulrushes and duckweeds.

The high consumption of duckweeds by coots is probably beneficial to the average marsh in Wisconsin, since this plant often occurs in a dense mass on the water surface of sheltered areas, and more valuable submergents are seriously retarded due to shading. This investigation thus failed to disclose any important competition for food between coots and shoal-water ducks at Horicon, Wisconsin, during the period studied.—BRUCE P. STOLLBERG, *Wisconsin Conservation Dept., Madison, Wis.*

REVIEWS

Natural History of Marine Animals. George Eber MacGinitie and Nettie MacGinitie. McGraw-Hill, New York, N. Y. 473 pp. illus. 1949. $6.00.

Deliberately writing for the student and the curious layman, the authors ably discuss the life histories and habits of representative species of each of the phyla of West Coast seashore animals. Well and clearly written in essentially non-technical language, the book devotes one section to the phyla of animals and one section to the marine conditions which influence the lives of marine animals.

The careful analysis given the ocean as an environment renders this book more valuable than the majority of texts on seashore biology. Amongst others, chapters on the foods of marine animals, variation and succession in marine populations, and burrowing as a way of life are significant new additions to seashore biology.

Because they chose to write primarily for the layman and the student, the authors limit technical language to scientific names

and to a summary of animal classification. Some technical information has doubtless been omitted. The great scope of the observations and the considerations of environmental conditions in inshore waters, however, should make this book useful to both the teacher and the marine research worker. —JOHN C. AYERS

Fur Farming for Profit. By Frank G. Ashbrook. Orange Judd Publishing Company, Inc. New York, N. Y. 8 vo. 429 pp., 166 figs. 1948. $4.00.

Prior to republication of "Fur Farming for Profit," there was no modern, comprehensive treatise on fur farming and its related problems. This book, a thorough revision and enlargement of the work originally published in 1928, is by a man who has given a lifetime to the study of fur animals, and who is intimately familiar with both the production and utilization phases of the fur industry. Indeed, no one short of such a background, gathered, in Mr. Ashbrook's case, throughout North America and in Europe and Asia, could produce this monograph-like book on fur farming.

Although the first edition appeared under the same title in 1928, the statement, "revised and reset," on the present title page, does not indicate the scope of the revision. The addition of new material, 106 more pages, more and better illustrations, and improved typography, make it a *new* book. The fact that it still sells for $4.00, as did the 1928 version, emphasizes its value by current economic standards.

The wide coverage of the new "Fur Farming for Profit" is well indicated by chapter headings: History and development of fur farming; Fur farming areas; Advice to beginners; Selecting a fur farming site; Essentials of breeding; Essentials of feeding; General management of the fur farm; Prevention and treatment of disease; Fox farming; Mink farming; Raising other fur animals; Transporting live animals; Pelting; Marketing furs; Associations and co-operatives; and Fur animal exhibitions. There is a good index, but unfortunately, no bibliography—a shortcoming charged before now to commercial book publishers.

To the reviewer, one of the valuable features of the book is the treatment accorded to species other than the "big two" of the fur farm, foxes and minks. Full space is properly given these two; but included in addition are: fisher, marten, skunk, raccoon, opossum, beaver, muskrat, nutria, chinchilla, and Karakul sheep. The dearth of information on the husbandry of nutria and chinchilla, particularly, and to a lesser degree on several other species, is appreciably rectified in the present book.

The chapters, "Pelting" and "Marketing Furs," offer good discussions on primeness, killing, skinning, fleshing, stretching, drying, cleaning, packing, and shipping to market, and should be of much practical value to all who handle furs—trappers, buyers, dealers, and fur farmers.—LEE E. YEAGER.

Field Manual of Plant Ecology. By Frank C. Gates. McGraw-Hill, New York. 137 pp. illus. 1949. $3.00.

Gates, in writing his *Field Manual of Plant Ecology*, had no intention of presenting a text—rather was it his purpose to prepare a tool to be used in conjunction with established courses in this field. For theory and discussions of ecological principles the student is referred to such standard texts as Weaver and Clements' *Plant Ecology*. After recognizing the limitations of scope which Dr. Gates imposed, the teacher or student will find much of value in his manual. Quadrats of many types, frequency determinations, simple map-making, transects, and charting methods are well covered. A section on the measurement of physical factors embraces soil analysis as well as temperature, precipitation, and other climatic variables. Qualitative and quantitative analytical concepts of ecology, study methods in plant succession, and many other topics are all presented with varying degrees of generality.

Perhaps the most valuable feature of the book is the extensive series of specific field exercises, designed to use simple, inexpensive equipment. In most instances the instructions are adequate, but for some exercises, insufficient information or inadequate references would make it difficult for the inexperienced student to proceed. This, though, is a minor criticism of the book, and in

general, those interested in plant ecology in the field will find in Dr. Gates' manual a fund of practical, well-presented information.—WILSON F. CLARK.

The American Wild Turkey. By Henry E. Davis. Small-arms Technical Publishing Company, Georgetown, S. C. viii+319 pp., illus. 1949. $5.00.

A more correct title for Mr. Davis' book would be "Hunting the Wild Turkey in South Carolina." It is not a compilation of modern knowledge of the species, as one might infer from the title. Nevertheless, the author has produced an entertaining volume which will be of great benefit to turkey hunters, from aspiring novices to time-proven experts.

For more than fifty years, Mr. Davis has hunted the wild turkey in South Carolina. His long range of experience, his excellent memory and his ability to write pleasingly justify his authorship of a book on his favorite sport. About two-thirds of the work consists of accounts of first-hand experiences in hunting turkeys, with incidental observations of their habits. The author confesses that "generally I was hunting rather than observing turkeys, and when a gobbler came within range I always shot him, which of course ended all chances of seeing any show the flock might otherwise have put on." However, the author does treat the history of the wild turkey, its distribution, life and food habits and preservation, referring to and quoting from well-chosen sources such as Mosby and Handley and McIlhenny.

The text rambles a great deal, and the chapter headings often are no indication of what may be found beneath them.

Some of the author's observations and recommendations are difficult to conform to good management practices or hunting methods. For example, in the Pearce preserve, which the author describes as one of the best game preserves he knows, the owners stocked Black Angus cattle and pine woods hogs. Mr. Davis does not remark on the effects of this livestock on the wild turkey range. Although he admits many occasions when he failed to locate dead or wounded turkeys, he will not tolerate the use of retrievers. He recommends firing at a bird which is out of range, on the chance that a lucky pellet might hit a vital spot.

The chapters on guns are excellent and in keeping with other volumes in the Samworth series.

While none of the five photographs are worthy of reproduction, the book is beautifully illustrated with a colored frontispiece by Weber and a number of fine line cuts and gravures by E. S. Smith.—OLIVER HEWITT.

Wildlife for America. E. H. Graham and W. R. Van Dersal. Oxford University Press, New York, N. Y. 110 pp. Illustr. 1949. $2.50.

"Wildlife for America," like the companion volume by the same authors which was issued in 1946, "The Land Renewed—The Story of Soil Conservation," is a picture account, in this case of "The Story of Wildlife Conservation." It was designed for youngsters of perhaps high school age, and the reviewer knows of no other volume which so effectively brings the story of wildlife conservation to this group. The book should be of inestimable value to teachers faced with the problem of teaching conservation in the junior and senior high schools.

A page of text on each carefully selected topic is faced by a full-page photograph illustrating this same topic. Over 50 such individual topics are covered in the one-page essays, and the professional wildlife biologists will be interested in seeing how carefully these topics have been selected to cover the entire gamut of wildlife management. An enumeration of a few selected topics covered will illustrate the scope of the book: history of wild life; effects of drainage and other types of land use upon wild life; vanishing species; introduction of exotics; food and cover; predators; interspersion of habitat types; hunting, fishing, and trapping; economic value of wildlife; biological values; protective laws; game farms and food patches; refuges; relations between agriculture and wildlife; field borders, and many others. The book is the ideal answer to the problem of what publication to present as a gift to a youngster who is becoming interested in wildlife conservation.—GUSTAV A. SWANSON.

The Avian Egg. By Alexis L. Romanoff and Anastasia J. Romanoff. John Wiley and Sons, Inc., New York, N. Y. xiii+918 pp., illus., 1949. $14.00.

"The Avian Egg" is a comprehensive review of the information available on the bird's egg. Since it treats broadly of the subject, rather than restricting itself to the egg of domestic fowl which has been studied most thoroughly, the book is of outstanding value to research workers in wildlife biology and ornithology. The senior author, who is professor of chemical embryology at Cornell University, is one of the outstanding authorities in this particular field in the world, and his original research in this field has made many of the important contributions, but the present volume is exceptionally important in bringing together between the covers of one volume all important work in this field. The comprehensive nature of the review is indicated by the bibliography, which consists of approximately 2,700 published items. Over 400 text figures illustrate the volume, and the text itself is exceptionally well written, being clear and concise to a degree seldom attained in technical treatises.

Every wildlife investigator concerned with reproduction in birds will find much helpful material in this volume. A great deal of foreign literature, hitherto quite inaccessible to the American worker, has been covered very thoroughly by the Romanoffs. Of particular interest to the wildlife researcher are the sections on egg formation, variability in external characteristics, heredity in egg formation, factors influencing egg laying, nutritive value of the egg, species specificity, immunological characteristics and other biological properties, and related subjects. The reviewer is confident that many wildlife biologists will find extensive use for this volume, and will be awaiting with great interest the one which Dr. Romanoff has now in preparation on bird embryology.—GUSTAV A. SWANSON.

Migration of Some North American Waterfowl, A Progress Report on an Analysis of Banding Records. Special Scientific Report (Wildlife) No. 1 (processed). John Aldrich and others. U. S. Dept. of Interior, Fish and Wildlife Service, in cooperation with the National Wildlife Federation, Washington, D. C. 48 pp. illus. 1949.

It has been many years since the Fish and Wildlife Service has been able to publish any comprehensive analysis of the bird banding records which have been accumulating so rapidly for over 25 years. The increased interest in waterfowl management during the last ten years has made frequent demands for this information as it pertains to waterfowl, and these demands have increased greatly during the past three years when the Service has set different duck hunting regulations on the different "flyways."

The task of analyzing these records is far greater than most persons would realize, even if they know that over 700,000 waterfowl have been banded in the U.S. and Canada, and over 100,000 recoveries have been reported. It became necessary, therefore, to call upon the cooperative efforts of virtually all of the individuals in the section of waterfowl management research, so the present report represents contributions by 16 biologists, each of whom has written a section on a single species.

A particularly interesting and valuable statement in the introduction by Dr. Aldrich clarifies the confusion which has occurred recently over the term "flyway." It seems worth while to quote this in full:

"The impression is inescapable that waterfowl migration is even more complicated than we had originally supposed; that it is difficult to make generalized statements with regard to migration pathways for even a single species, let alone waterfowl in general; and that we need a great deal more information based on banding, particularly on segments of breeding and wintering populations which have not already been banded, before we can manage those populations satisfactorily. The following reports will be found to be full of unanswered questions which can be answered only by further banding in specific locations and seasons.

"The term 'flyway' is used in this report in two different ways. In one sense it is used to refer to a species flyway, which is a rather definite migration pathway utilized by certain populations of a single waterfowl spe-

cies. The term is used in another sense to refer to administrative flyways (capitalized when used with the name), which are four separate areas, the boundaries of which conform arbitrarily to state lines and which approximate as nearly as possible the regions through which major groupings of species flyways pass. The administrative flyways are distinguished to facilitate differential shooting regulations and other management practices, and although related to species flyways, should not be confused with them."

Each species has the records of waterfowl banding recoveries indicated clearly by symbols which show clearly the point of banding and recovery. In many cases the maps are reproduced in color for greater definition. The publication summarizes in a concise and easily understood form the information now available on the migration routes of North American waterfowl, and it is perfectly clear that every biologist, game administrator, and sportsman who is interested in waterfowl will need this publication, and will use it constantly. Each reader will find many surprising and interesting facts regarding the migration routes of species with which he may have thought he was thoroughly familiar.—GUSTAV A. SWANSON.

OBITUARY

GEORGE BALCH LAY

1895–1948

George Balch Lay, a Charter Member of The Wildlife Society, was born at Concord, New Hampshire, on May 4, 1895. His undergraduate work was done at Yale University and the University of North Carolina. In 1932, he received from State College, North Carolina, the degree of Master of Science in entomology. While there, he was also active in bird clubs. He was attached to the North Carolina Forestry Service prior to spending the years 1935–1946 with the U. S. Biological Survey and Fish and Wildlife Service. His work with those organizations was in rodent control in the Southeastern States and in New England. He resigned in 1946, and in April 1947, went to Korea as a civilian employee of the U. S. Army in charge of insect and rodent control. He died there from cancer of the liver on May 6, 1948. He was buried at Chapel Hill Cemetery, Chapel Hill, North Carolina. He is survived by his wife Anne and two young daughters, who reside at Hopkinton, Massachusetts, where he lived during the latter part of his New England work. Brief obituaries from which the present one has been compiled were published in The Service Survey. June 1948, pp. 19–20) and The Auk (66(2), April, 1949 [May], p. 232).—W. L. MCATEE.

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